4 CARBON SEQUESTRATION PRACTICES AND EMISSION RELATED ACTIVITIES

Upon describing Idaho's natural resources, land use and management characteristics, the potential land-based practices that may provide future carbon sequestration and greenhouse gas reductions need to be explored. This section describes numerous practices and related activities that Idaho's landowners and business communities may adopt which can sequester carbon and reduce greenhouse gas emissions at various locations throughout the state. This report primarily focuses on private and state lands. Public land activity could benefit the state from similar activities.

4.1 CARBON SEQUESTRATION IN IDAHO

While scientists believe that rising levels of carbon dioxide and other greenhouse gases are contributing to global warming, the extent has been difficult to determine. While limiting fossil fuel consumption is one method of reducing emissions of carbon to the atmosphere, another is to increase the sequestration of carbon in sources on the land. Carbon sequestration is the use of practices, technologies, or other measures that increase the retention of carbon in soil, vegetation, geologic formations, or the oceans with the effect of offsetting carbon dioxide emissions from other sources. Agricultural producers and forest land owners can help address greenhouse gas concerns by implementing practices that cause the land to act as a greater sink for carbon and that decrease agriculture and forest related emissions of greenhouse gases. Biofuels production can substitute fossil fuel use in the transportation sector and reduce greenhouse emissions greatly, while reducing our reliance on petroleum. Many of the activities that increase the organic content of soils, in trees, or reduce related greenhouse gas emissions can also increase agricultural productivity as well as improve soil, air and water quality.

Idaho's private landowners could profit from carbon sequestration if certain types of carbon trading or other financial incentives are put into place. There are, however, many questions about whether substantial carbon trading markets will develop in the United States and, if so, what form they might take. Development of a substantial carbon trading market is dependent upon international agreements that are still evolving and on various national and international initiatives. Little federal government action has resulted in the development of strong carbon markets in this country, however, the U.S. government has not done anything to prohibit American citizens and companies from participating in carbon sequestration activities. Some environmental interests, however, are against allowing industries to offset their emissions through carbon sequestration activities.

Though with the uncertainties associated with climate change and sequestration opportunities, the potential for Idahoans to profit could conceivably be enhanced if the state takes actions to ensure it can act quickly should significant carbon markets develop. If a carbon storage market does not develop but additional efforts in put into the implementation of various conservation practices, the benefits of increased conservation and improved land management related to carbon sequestration may still provide a long-term economic benefit to the state.

The advantage of carbon sequestration to Idahoans is, though it may contribute to curbing global warming and the perceived related impacts from such warming, economic benefits can be achieved. This report does not elaborate on the perceived effects of climate change and how the state may reduce the impacts, but focuses on the potential benefit that the state as a whole and its landowners can receive by participating in carbon markets. The most important first step is estimate the quantity of carbon that *might* be sequestered through agricultural and forestry practices and other related activities. The second step is to define the methodology in which to actually verify carbon sequestration and other related greenhouse gas reductions. Upon developing that methodology, which will not be entirely accomplished here, a process to assist the state and its landowners in participating in carbon markets would follow. This report and its evaluation of numerous practices will set the stage for a further and more comprehensive exploration of specific elements possibly desired in carbon sequestration markets.

The potential international and national law changes regarding emissions, possibly in response to international and national interests, would have the most relevance for Idaho agriculture and forestry if there become national carbon emission limits (restrictions) and related actions allowing for carbon sequestration to offset some of those emissions. The level of the emission offset by carbon sequestration would likely be determined by restrictions and the market value of a metric ton of carbon.

When evaluating the potential agricultural and forest related practices that can sequester carbon or reduce emission losses, the practical limits of sequestration needs to be addressed. Some practices will store carbon over a significant amount of time and achieve the physical upper limit of carbon storage. However, these practices may need to be in place for many years and operated in such a manner to achieve optimum carbon storage. At some point, the management needed to add still more carbon to land that already has high carbon levels may become cost prohibitive. If no program or incentives are in place to ensure continual application and maintenance of these practices are continued, the carbon previously stored could be re-released, which may not suit well within a carbon market, likely driven by regulations.

A large amount of carbon has been lost to the atmosphere due to the development to agricultural production. Tillage practices have caused minerals to oxidized at much greater rates than that of those undisturbed soils, but there are practices that can sequester carbon back into the soil, possibly back to the original amount. These carbon sequestering practices will generally have substantial ancillary benefits to the economy and natural resources. Most of those practices have in fact been the subject of government programs or support due to their conservation values alone without strong regard to their additional carbon sequestration benefits. Some of the agricultural and forestry practices and related activities that can increase carbon sequestration and/or reduce related greenhouse gas emissions are listed below:

- Residue management (direct seed, no-till),
- Nutrient management,
- Windbreaks,
- Short rotation woody crops,
- Riparian forest buffers,
- Prescribed grazing,
- Range and pasture planting.
- Methane reductions from livestock and waste storage ponds,
- Biogas recovery,
- Biofuels (ethanol & biodiesel),
- Afforestation and reforestation (forest, pasture, croplands).

The overall potential to sequester carbon and reduce related greenhouse gas emissions from some of the agricultural and forestry practices may be significant. For example, the potential benefits from combined total cropland and grazing land related emission reduction and sequestration practices could be over 400 million metric tons C (MMT C) of carbon per year. However, there is not total agreement on sequestration potential from various practices, especially on such topics as grazing land. In addition the amount of new or additional carbon sequestered may begin to decline as a soil reaches its capacity. Also, several uncertainties exist with respect to how these practices or the sequestration that results are to be accounted for in a national or international market, if sequestration is ultimately utilized to achieve global emission reductions

It should be noted that the amount of carbon in storage and the potential for additional carbon storage do not necessarily correspond. One of the key questions in carbon storage is not just how much carbon is stored by a land use, but how easy it is to either lose that carbon through emission to the atmosphere or gain additional carbon storage. In other words movement through the carbon cycle is as important as the size of the carbon stock. Another question revolves around whether currently existing stocks of carbon may be credited under new carbon management systems versus crediting only gain or loss of carbon stocks. It is likely that only those additional quantities of carbon stored would qualify as carbon credits (offsets). Thus in this report, the actual amount of stored carbon in soils and biomass is not the main focus, but the addition through practices and activities.

4.1.1 Ancillary Benefits of Carbon Sequestration Practices

There are a number of ancillary benefits, along with some potential negative impacts, associated with many of the carbon related practices. One of the most important of these is to protect and maintain the long-term productivity of the soil in the state through reduction in soil erosion. For example, quality criteria in the NRCS Field Office technical guide generally allows a soil loss of 5 tons/acre/year (0.032 inches/year) which is 16 times faster than an average rate of soil formation (estimated at .002 inches per year). Although the rate varies with individual soils, 5 tons/acre/year is generally close to "T" (tolerable level of soil erosion that maintains soil productivity). 1992 data indicates that 21.4% of U.S. cultivated cropland was eroding at greater than "T" as a result of sheet and rill erosion, and 16.1 % was eroding at greater than "T" from wind erosion (USDA, 1997a). The negative yield impacts due to soil erosion are felt on cropland as well as pasture and rangeland.

Other additional benefits of conservation practices, especially residue management, are a decrease in fossil fuel use, time savings for operators, moisture conservation with resulting yield increases, better water quality, and a reduction in off-site sediment damages. Most all of these practices to be discussed in this report are or can provide numerous natural resource and economic benefit to the state.

4.1.2 Carbon Sequestration Practice Evaluation Criteria

To determine what practices are feasible in storing carbon, either in the soil or in above-ground biomass, or reducing a greenhouse gas emission, there needs to be consistent and comprehensive evaluation. Practice effectiveness, acceptability, cost, implementation capability, operation and maintenance capability, monitoring and verification capability, and ancillary benefits, are such criteria to evaluate a practice individually and deem whether or not it is feasible. When these following are used comprehensively to evaluate the overall potential of their use in the state, it results in a better understanding of what practices might most beneficial to the state. Appendix 5 shows a numeric rating system (a table) that the Advisory Committee used to initially evaluate each practice and activity discussed below. Those practices or activities that rated highest, utilizing each of the criteria below (with and without cost), will most likely will be those chosen by landowners and other carbon market participants to offset greenhouse gas emissions.

4.1.2.1 EFFECTIVENESS

How much carbon sequestration can occur or emissions offset by the individual practice, and its duration of its effectiveness is important. The certainty of results from a type of practice or actions and how well the public and government retains the practice as viable is important. The effectiveness of policies during economic fluctuations and growth, and technological change, are also variables that need considered while evaluating effectiveness. This evaluation criteria just looks at the individual practice in one location, not on a state-wide scale. Upon discussing its individual effectiveness, a state-wide estimate of sequestration (or emission reduction) presented (see Appendix 10). A summary of the state-wide benefit from the adoption of these practices are presented later in the report in Chapter 8.

4.1.2.2 ACCEPTABILITY

To what degree farmers, ranchers, and forestry land owners accept and adopt a practice is very important in forecasting the potential level of sequestration in the State. Under non-regulatory programs, such as those administered by the Idaho Soil Conservation Commission or within a carbon market, the cultural and social acceptance of a practice will determine its success in being implemented. Regulatory programs, mandating specific practices to be implemented, may or may not increase acceptability upon enactment of mandate. However, over a few years, the practices often become more acceptable and common, if not detrimental to a business, Economics play a large role in practice acceptance, along with numerous other factors, which are not easily analyzed to predict acceptance levels. Acceptability will be estimated primarily by looking at the historical application of practices and based on experience and expertise of those assisting with this report.

4.1.2.3 COST

For every dollar spent and time involved in setting up and implementing actions, there should be some benefit. Costs are, whether for installation, operation, or maintenance, very important to the landowner or operator. If installation costs are high, the investment must be replaced with adequate return to justify the practice, and to allow for its longevity. Alternatives may also be evaluated with a simple cost-to-benefit analysis, to determine if costs can be absorbed or possibly reclaimed later. Administration costs are also important, as with an agency or private organization responsible for a practice's implementation, operation and monitoring.

There may also exist transaction costs incurred while connecting the supplier of carbon "credits' to buyers. Aggregation of credits from multiple sources will increase transaction costs. Transaction need to be consideration in the evaluation or creation of local or state-wide carbon markets. If transaction costs are too great, minimal trading or selling of carbon credits will likely occur. Verification costs may be considered a part of transaction costs, along with administration costs. Legal costs may also enter in and need to be evaluated, but not necessarily on a practice-by-practice basis.

4.1.2.4 IMPLEMENTATION CAPABILITY

This evaluation criteria looks at the practicality and capability of installing the practice, as well as other conditions, such as legal constraints, permits, and landuse zoning. An example of a legal constraint may be with dairies and feedlots, where animal wastes are to be handled in a limited manner and may not necessarily coincide with methane reduction practices. Waste treatment lagoons are acceptable, but they produce methane and odor problems. If an operator wished to land apply manure for aerobic treatment, then nutrient management criteria may be exceeded. Also, waste incorporation into soils does not work well with a direct seed or no-till operation, where excessive soil disturbance occurs with tillage.

4.1.2.5 OPERATION AND MAINTENANCE CAPABILITY

Practices need to be operated properly and maintained in order to be effective over its expected life-span. Costly operation and maintenance on certain practices may not be acceptable or practical in achieving a high level of carbon sequestration, which should be evaluated prior to installation if possibly. Operation of a practice may need to be adjusted to maintain its highest or most feasible level of sequestration. Most practices should not require additional operation or maintenance effort beyond what they already require today, however, for longevity of carbon storage, there may be no allowance for departure from the practice due to the nature of carbon cycling, especially in soils.

4.1.2.6 MONITORING AND VERIFICATION CAPABILITY

Some activities implemented under new programs may or may not be actually measured to deem a success. Idaho should be careful not to eliminate practices or activities that are difficult to actually measure, but allow for alternative monitoring techniques, that still may show benefit from implementation. Verification is for the purpose of ensuring that a practice is actually increasing stored carbon by a minimal amount or reducing a given amount of emissions. Monitoring may require record keeping, and audits, where verification will likely require on-site measurement techniques. The capability of either monitoring and verification should be evaluated prior to installation.

4.1.2.7 ANCILLARY BENEFITS

Some actions initiated due to new greenhouse gas related programs may have positive and negative impacts locally and off-site. For example, tree planting programs that sequester carbon, may also reduce soil erosion and improve water quality, but if changes the landuse status, effect property values and taxation. In some cases, ancillary benefits may justify installation of practices without additional funding from carbon markets.

4.2 AGRICULTURAL CROPLAND ACTIVITIES

USDA estimates from 1998 indicate a U.S. cropland soil sequestration potential of 154 million metric tons of carbon (MMT) or about 8.4% of U.S. emissions annually. Another source indicates improved management of U.S. cropland has an estimated potential to sequester between 75 and 208 MMT per year. This figure rises to 123 to 295 MMT when the potential offset from use of biofuels, reduced fuel use, and reduction of eroded sediments are added (Lal, et. al., 1999).

There is some evidence that soil organic content is likely to increase in dry areas when soil is irrigated, since most soils in dry areas have naturally low levels of soil organic content. Irrigation water management has significant carbon sequestration potential, in the irrigated portion of the Snake River plain for example. The extent to which fuel consumption required by irrigation has likely offset the carbon storage benefits of irrigated land needs however.

Idaho's calcareous soils, found mostly along the southern Idaho Snake River plain within a semi-arid climate, likely have increased soil organic content because of irrigation, fertilizer, and residue inputs. Farmlands within higher precipitation areas of the state have lowered soil organic content, with little or no irrigation development. Future carbon sequestration is likely to occur differently among these different areas within the state. Climatic conditions and other soil characteristics may enhance or limit the amount of carbon sequestered. The types of management practices will effect carbon sequestration rates. Some soils may be near or at soil capacity and changes in management may not increase soil carbon levels.

Afforestation of non-forested areas may provide a substantial amount of carbon sequestration due to increased woody biomass (wood). Soil carbon levels may also be increased under newly forested areas, where woody biomass increases and tillage practices are eliminated. A combination of practices on a farm might be most feasible to maintain conventional production and provide the greatest amount of carbon sequestration.

Potential biofuel sources that are currently produced in Idaho are corn, wheat, barley, and canola. Agricultural products can be utilized to reduce transportation related fossil fuel emissions through the use of biofuels. With predicted increases in U.S. and world energy demand, biofuels provide one method of meeting that demand without significantly increasing atmospheric carbon levels. Potential U.S. biofuel production could result in a reduction of about 5.3 percent of U.S. carbon equivalent emissions via replacement of fossil fuels (USDOE, 1999). Biofuels will be discussed more in-depth within its own section later.

Photosynthesis removes carbon dioxide (CO_2) from the atmosphere and stores the carbon in plant materials and soils. U.S. cropland soils currently sequester 20 MMT/yr (of carbon per year), and have an estimated biophysical potential to sequester 60-150 MMT/yr more; grazing lands could sequester up to another 50 MMT. To put this in context, 60-200 MMT/yr is about 12–40 percent of the reduction that would be needed to return expected 2010 U.S. greenhouse gas emissions to their 1990 level. Carbon sequestration can be accomplished through many alternative practices.

4.2.1 <u>Residue Management (No-till, strip-till, an direct seed)</u>

4.2.1.1 DESCRIPTION

This practice is the management of the amount, orientation, and distribution of crop and other plant residues on the soil surface, while growing crops in narrow slots, tilled or residue free strips in soil previously untilled by full width inversion implements. The definition adopted by the Pacific Northwest Direct Seed Association is "a method of planting and fertilizing done with no prior tillage to prepare the soil. Includes systems that plant and fertilize into undisturbed soil, as one pass, and those that fertilize first and then plant, as two passes". See the NRCS conservation practices web site for more details regarding this and other practices (http://www.id.nrcs.usda.gov/Engdwnld/construction_specs.html).

Residue management, a term representing multiple types of tillage techniques such as no-till, direct seeding, reservoir tillage, and also known as conservation tillage, applies to environmentally friendly planting methods that help soils retain nutrients after completion of the planting process. Tillage systems that keep the majority of the crop residue after planting are considered to be no-till or direct seed. In this discussion, direct seed and no-till will be the primary focus, which are only those types of tillage that may sequester carbon.

4.2.1.2 EFFECTIVENESS

This practice is very effective in reducing sheet and rill erosion, wind erosion, and irrigation-induced erosion. Water infiltration is increased, organic matter increased, and possibly increase agronomic yields. Estimates on organic matter, soil carbon increase, may range from 0.12 metric tons of carbon (MT C) to 0.24 MT C, (Lal et al. 1998) The PNDSA has adopted 0.15 MT for northern Idaho conditions and direct seed practices. Effectiveness will vary depending on soils, climate, residue management, starting soil organic matter, pH, and other factors.

Soils have natural carbon-carrying capacities, and it may be difficult or impossible to increase their carbon content beyond these limits. Most soil carbon gains from residue tillage are achieved within approximately 20 years, but the carbon stored can be released later if farmers revert to conventional tillage practices. Reversion to conventional practices will result in most of the carbon being released back into the atmosphere within a few years. However, temporary storage of carbon may offer significant benefits by reducing the rate of increase of atmospheric CO_2 until more permanent solutions are found.

Intensive soil tillage is recognized as a significant factor causing soil organic matter oxidation (CO_2 emission) in cultivated soils. Intensive tillage, particularly with soil inversion (plowing) enhances decomposition by exposing organic matter protected within soil aggregates and by increasing soil temperature. Reduced tillage, and particularly no-till practices, have been shown to promote higher levels of organic matter in many systems, where productivity and organic matter inputs are not adversely affected. An analysis of 28 paired comparisons from no-till versus full tillage treatments in 19 long-term experiments (duration of the experiments ranged from 5 to 20 years) in Canada, Europe and the United States showed mean increases of soil organic matter under no-till of 0-30 % C, with an average of about 10 % (Paustian *et al*., 1997).

The Pacific Northwest Direct Seed Association and ENTERGY agreement uses a conservative carbon sequestration rate of 0.15 MT C per year under a direct seed system, which applies to northern Idaho, including eastern Washington state. A Iowa carbon budget for 640 acre farm, under a conservation tillage corn/soybean rotation was estimated to sequester 0.16 MT C/ac/yr (Hurley et al. 2000). Other various sources, such as from Bruce et al. 1999, and Lal et al, 1998 estimate sequestration rates at 0.16 and 0.20 for no-till respectively. These rates seem to be closely representative and likely applicable to northern Idaho, possibly eastern Idaho, where precipitation rates are higher than southern parts of the state. Where precipitation is low and soils have high pH, and irrigation is necessary to grow numerous crops, the sequestration rates are likely lower. The rate used by PNDSA also includes diesel fuel savings as compared to hours typically used under conventional tillage. The 0.5 MT CO_2e (converted from C to CO2 by 3.67) rate is a fair estimate for Idaho, but excluding the estimated savings of diesel fuel use, which has been estimated at a rate of 0.004 MT CO_2e. Some differences will occur, though under different soils, such as in Southern Idaho, where this soil carbon rate may be less, due to pre-agricultural differences in annual precipitation, irrigation, SOM, pH, and other factors.

Assuming that Idaho currently has about 4.5 million acres in active cropland, if 36% of those acres were converted to direct seed or no-till, then 0.8 MMT CO_2e could be sequestered. There are nearly 270,000 acres currently in some form of residue management (CTIC, 2002 – http://www.ctic.purdue.edu) which is sequestering 135,000 MT CO_2e. The percent of acres converted to no-till or direct seed is increasing, mostly in Northern Idaho. An additional 0.1 MMT CO_2e would be reduced in CO_2 and N_2O emissions relative to the traditional cropland management. If a carbon market came into existence, or some other program, and with it a substantial amount of funding to pay for new equipment and some for of crop yield insurance, then direct seed and no-till acres may increase much more. A whole-farm analysis would need to be done to better estimate actual carbon credits available for purchase.

4.2.1.3 ACCEPTABILITY

Residue management's acceptability by farmers varies from region to region in the nation. In Idaho, there are pockets of farmers widely accepting direct seed and no-till, completely changing their operation from conventional within a few years. The majority of the state's farmer's, however, have not accepted residue management widely, especially where multiple crops are grown and within higher elevations. Surface irrigation practices and commercial cash crops have also been a deterrent in the acceptance of this practice. Where multiple crops are grown, with small seeds and cultivation is important for weed control, given a rigorous irrigation schedule along with that, tillage practices that leave an amount of residue on the field's surface that can disturb small seeds or can clog irrigation furrows are not accepted. Tillage practices have, however, been modified for some crops and by some progressive farmers and have been successful. Cultural or tillage traditions, is likely the primary barrier for a wide-spread acceptance of this practice in Idaho.

While already widely practiced throughout the nation residue management, is also an important strategy for reducing on-farm energy use, labor reductions, reduced erosion, and smaller nutrient loss from soils. Almost any dry land crop can be grown under a residue management system (no-till, ridge-till, or mulch till). Under irrigation, primarily surface irrigation, residue tillage may more complex but is achievable. Crop residues must be maintained on the soil surface throughout all parts of the year to conserve soil and allow for maximum moisture entry and storage in crops. Spring warming of Eastern Idaho soil temperatures, primarily those in higher elevations, are considered hindered by high residues left on the soil surface, thus this practices has not been readily adopted in this area. In contrast, Northern Idaho farmers have more readily adopted additional residue management practices, primarily direct seed.

4.2.1.4 COST

The initial investment of residue management may be costly where a complete adoption of no-till or direct seed occurs, where new equipment is purchased. Where the same tillage equipment covers large amount of acres, every year, the cost should be relatively low. In regards to increasing soil carbon with this practice, the amount of acres to be treated, whether or not equipment is already available, and the ability for soils to further store carbon are the major factors in determining a cost. There should be relatively low annual costs to the farmer, once no-till or direct seed practice has been adopted, compared to a conventional tillage operation. Less fuel usage, less time, and hopefully less herbicide use over a long period of time should occur.

4.2.1.5 IMPLEMENTATION CAPABILITY

The initial investment of residue management may be costly where a complete adoption of no-till or direct seed occurs, where new equipment is purchased. Some modification of existing conventional drills and planters may be done for a few crops and has been done. Where new equipment has been purchased, large acres are usually acreage farms are involved. Many of the northern Idaho farm fields are much larger than southern Idaho fields. The large-scale farm, in which to work in a residue management operation, requires much less field adjustments between fields, where there are fewer but larger fields. Covering multiple acres without having to change equipment or seed simplifies the practices. Where no cultivation practices or irrigation is involved, this too simplifies adoption of this practice.

4.2.1.6 OPERATION AND MAINTENANCE CAPABILITY

Once implemented, operation is similar from one year to the next, except for the changes dictated by crop type and its nutrient, pesticide, and irrigation water management associated with it. Maintaining this practice over along period of time will be necessary to ensure soil carbon levels are maintained and increasing, up to the soil capacity. If at any time soils are inverted, such as with a plow, most soil carbon built up by the previous years no-till or direct seed operations will likely be lost within a very short period of time. Therefore, maintenance and constant attention to the practice will have to occur for soil carbon levels to be maintained and increased. Maintaining this practice should become easier after of use.

4.2.1.7 MONITORING AND VERIFICATION CAPABILITY

Along with field inspections to ensure that the practice was implemented correctly, soil testing or equivalent procedures will be needed to verify soil carbon levels are being maintained or increasing. Prior to the adoption of the practice or entrance into an agreement, there will likely need to be soil testing to establish a baseline soil carbon level. Carbon levels in soils, most likely those in or around 1990, (Kyoto baseline year), would likely have to be surpassed for there to be a carbon 'credit' to sell. If carbon levels are not found to be increasing a field, based on actual field measurements or adopted scientifically-based modeling, then it would be difficult to justify a sale of carbon credits. Any monitoring requirements of this practice would likely need to be outlined within a contract between the buyer and seller of carbon. Annual post-planting field inspections and some periodic carbon storage verification may likely be needed.

4.2.1.8 ANCILLARY BENEFITS

It is estimated that no-till systems can minimize erosion by up to nearly 95%, and reduce pesticide and water runoff by 70%. Farmers can benefit greatly from no-till planting because it can reduce their commercial fertilizer purchases and applications and lowers fuel usage. Surface water quality of adjacent streams and lakes are also going to benefit from such a practice.

4.2.2 Cover Crops

4.2.2.1 DESCRIPTION

Cover crops are usually planted with grasses, legumes, forbs, and other herbaceous plants, after the harvest of another short-season crop, for the purpose of maintaining soil moisture, reduce erosion, and add nutrients to the soil. Specific types of cover crops, while under a no-till or direct seed tillage operation, can and some carbon to its soils, up to the soil carrying capacity. Rotations will dictate when and how many years a cover crop can be planted within the farm rotation. Cover crops are generally tilled into soils the following spring, however, again, this practice would require no tillage to occur to increase soil carbon.

4.2.2.2 EFFECTIVENESS

Where no-till and direct seed can sequester about 0.9 MT CO_2e, a cover crop added to a rotation, can possibly sequester 0.3 to 0.5 MT CO_2e within the year that it is in place. The above-ground residues may not add any significant amount of carbon to soils if conventional tillage is continued. Even with the conversion to no-till or direct seed, the amount of carbon added to soils will be limited to soil capacities. Organic matter may only increase by up to 1% in most areas of the state with no-till and cover crop practices. If it assumed that the acres of cover crops are incorporated into the rotation is the same as those converted to no-till and direct seed, then nearly 36% of the total 4.5 million cropland acres would then produce around 0.2 MMT CO_2e, assuming that cover crops are only used 30% of the time within a crop rotation. This amount of sequestration is about 22% of that sequestered under a no-till operation. A whole-farm analysis would need to be done to better estimate actual carbon credits available for purchase.

4.2.2.3 ACCEPTABILITY

Most crop rotations have been adopted by cultural and family historical precedence. Cover crops, would also be adopted similarly. Often, crop prices may drive what crops are grown a specific year but does not generally cause a major shift of overall farm crop varieties. Cover crops may not likely have any return, and may increase some management time. Weed control, hopefully, would be easier with cover crops, but may not initially. The potential of shifting to more cover crops, such rye grass or winter peas, is low for Idaho, principally with the need for a change in tillage practices. Changes in tillage practices that follow a shift in crop varieties, crop prices, and historical barriers would weigh in heavily on a farmer's decision to change to a new rotation with cover crops. Fields that are rented out to other farmers having already made a shift to less intensive crop rotations may have the highest level of acceptability, such as when a farmer is near or at retirement but does not choose to sell the property. Other industries, such as in the cash crop or seed crops, may still provide large incentives for farmers to stay in an intensive rotation, without cover crops possibly interfering with annual crops and tillage needs.

4.2.2.4 COST

The costs of switching rotations, including some cover crops, should be relatively low, but would need to incorporate new tillage practices for carbon sequestration purposes. Additional cost of planting a cover crop would need to be absorbed initially, where benefits are not likely to be felt. Long-term commitment may see some return with less pesticide and disease control costs. Fuel use may also increase with cover crop planting.

4.2.2.5 IMPLEMENTATION CAPABILITY

For a farmer to add a cover crop, in essence, a new crop rotation, it should not interfere with any existing farm subsidy programs. Local cultural traditions usually play a role in the adoption of cover crops, but to what extent, that is not known. Cover crop use in dryland areas may limited if soil water is not available, similar to irrigated areas if there exists no additional water for establishment. Growing seasons lengths would also limit success.

4.2.2.6 OPERATION AND MAINTENANCE CAPABILITY

Specific crop rotations that are not much different from what a farmer is already practicing would not be difficult to maintain, but cover crops would add some complexity. If tillage practices must change with a change because of changes in rotation and added cover crops, then operation and maintenance capability efforts may need adjusted and increased to ensure desired benefits such as a minimum level of soil carbon and some return on investment. Planting and harvest periods would need additional planning to ensure that the cover crop was installed and successfully established for winter soil protection.

4.2.2.7 MONITORING AND VERIFICATION CAPABILITY

Verification of a specific cover crop may require contractual language to ensure the rotation is carried out and is verified as such. Field inspections and planting records may both be needed to truly monitor application. Field site soil sampling may also be needed to verify that soil carbon levels are truly increasing due to the practice, but would be difficult to weight out tillage effects. Continual and intensive soil testing, however, would generally not be acceptable as implementation costs would rise substantially as compared to traditional soil testing procedures.

4.2.2.8 ANCILLARY BENEFITS

Less soil erosion will occur over winter months with cover crops. Field maintenance, due to rill and gully erosion would be less. Increased soil nutrients or the uptake of carry-over nutrients may benefit the farmer and off-site natural resources. Local water surface and ground water quality may benefit with less soil erosion, and lower soil nutrient levels due to improved utilization and less fertilization requirements. Fewer pesticides may be used if cover crops limit weed infestations.

4.2.3 Grassland Cover

4.2.3.1 DESCRIPTION

Permanent grassland cover, similar to what occurs under the USDA-Conservation Reserve Program (CRP), maintains soil moisture, reduce erosion, and add nutrients to the soil. Specific types of grasses are prescribed that will be successful for at least 10 years. No cultivation is allowed on fields under the CRP, but some weed maintenance is necessary, which may include mowing and spraying. Soil carbon will increase under a vegetative cover, where soil disturbance is occurring.

4.2.3.2 EFFECTIVENESS

Where no-till and direct seed can sequester and cover crops may increase soil carbon about 0.45 million MT CO2e per year, so could grassland cover. Eliminating commercial cropping from a field, planting a perennial plant or mixture of plants, and maintained for long periods of time (at least 10 years) will increase soil carbon, but only up to its soil capacity. Organic matter may only increase, at most 1% in the state with no-till and cover crop practices, so to with this practice. If it assumed that the number of grassland acres are similar to the existing CRP acres (near 700 thousand), then those acres could sequester up 0.34 MMT CO_2e/y, but only up to so many years. The number of acres potentially available for this practice may only be 20% of the total 4.5 million acres of cropland. Upon reaching soil capacity C, maintaining that soil carbon level would need to occur for successful long-term emission offset. A whole-farm analysis would need to be done to better estimate actual carbon credits available for purchase.

4.2.3.3 ACCEPTABILITY

This practice would be much more acceptable if payments would cover property taxes, and supply typical net returns from commercial crop production. Generally, CRP has been limited to dryland farming rates, which are much lower compared to irrigated cropland rental rates. If payments were increased 3 to 4 times for irrigated areas, then this practice may be more acceptable throughout the southern part of the state. Otherwise, this practice may likely only be as successful at the existing CRP payment level. Rural-urban areas may have a higher likelihood of acceptance, where wildlife habitat and aesthetics may be more important than crop production.

4.2.3.4 COST

The cost of planting grass seed is relatively low, compared to some other crops, however, there is no net return on investment where it is not likely harvested. Maintenance costs are relatively low if germination and the first year's growth is not stunted by drought, disease, or weeds. Continued care will need to be taken in some areas however, because of fire hazard, insect, and weed problems, which could increase costs. In some cropland areas, where water availability is limited, planting costs will likely be higher because of replanting, where irrigation may not be available or is not adequately provided.

4.2.3.5 IMPLEMENTATION CAPABILITY

For a landowner to give up a commercial cropping operation on a field or farm, it may be a difficult decision to make. However, this is a very simple practice to implement. Local crop markets should not be impacted with this practice if acres are kept below 25% of most crop market production. Water availability is the key to this practice being implemented successfully.

4.2.3.6 OPERATION AND MAINTENANCE CAPABILITY

As mentioned before, successful germination and a first year's growth will determine operation and maintenance of this practice. Weed, insect, and fire prevention and control will be necessary, regardless of location. Adjacent to public lands or lands with poor maintenance, fire hazard and insect problems are likely to be more of a concern. In irrigated agricultural areas, periodic irrigation will still be needed unless shallow ground waters are adequate for grassland growth. Optimum growth may require similar irrigation usage on grasslands as with existing hay land.

4.2.3.7 MONITORING AND VERIFICATION CAPABILITY

Verifying that grassland cover is successful and adequate is relatively easy. Quantifying a carbon levels is also simple, if adequate soil samples are taken. If may be difficult to establish an exact level of carbon increase, however, if baseline data has not been generated similarly to what is required under a carbon market contract. In most cases, though, verification through soil sampling can establish baseline conditions for the first year of a contract.

4.2.3.8 ANCILLARY BENEFITS

Increased wildlife habitat, decreased soil erosion, and increased soil tilth will improve under a grassland practice. Water quality in surface and ground water bodies will also benefit from less soil movement and nutrient loss. Weed control in some areas may benefit from permanent perennial vegetation, holding back weed invasions. Some grasses, if more desirable to insects than surrounding crops, may be impacted more but would reduce the damage to those adjacent higher value crops. Some negative impacts could be known if too many acres were converted to grassland, rather than cropland where fertilizer sales and other agricultural relate products are no longer needed.

4.2.4 Grassed Waterways

4.2.4.1 DESCRIPTION

A grassed waterway is designed to be a natural or constructed channel that is shaped or graded to necessary dimensions for transferring overland flow, safely, to a field's outlet. Waterways are seeded with various grasses, but sometimes depends on soil slopes and upland runoff conditions. This practice can increase soil carbon within the waterway area, while reducing tillage and fertilization emission losses. Typical widths of these channels are 15 feet or greater, based on expected runoff flows. These are typically installed in dryland cropland areas.

4.2.4.2 EFFECTIVENESS

While these waterways are in place, it can sequester carbon in soils and reduced emissions if fertilization is not occurring within the waterway itself. If they are periodically removed, then only reduced emissions may occur, where tillage will likely release most all of the previously stored soil carbon. Soil capacity may limit the amount of stored soil carbon. If it assumed that up to 20% of cropland acres were available to install grassed waterways, then those acres actually in grass (in waterways) could sequester up to 4,142 MT CO_2e/y. These waterways are only assumed to take up 1% of a cropland acre. A whole-farm analysis would need to be done to better estimate actual carbon credits available for purchase.

4.2.4.3 ACCEPTABILITY

Grassed waterways are more acceptable and practical on dryland farms, where they don't interfere with irrigation system management. Even with no-till or direct seed in practice, this practice may be practical to install because of a greater gully or swale protection. There are, however, initially considered an obstruction to farming, but upon installation, tillage and spraying is quickly modified and benefits become greatly appreciated.

4.2.4.4 COST

The cost of planting grass seed is relatively low, compared to commercial crops, however, there is no net return on investment, except where erosion maintenance costs are reduced. Replacement of grassed waterways will occur periodically, therefore maintenance costs. If germination is not successful, then re-planting will raise installation costs. Weed control may be necessary, but may not increase costs compared to typical cropland weed control. Some grassed waterways may additional grading, drainage tile, and proper outlet structures, which will increase installation and maintenance costs.

4.2.4.5 IMPLEMENTATION CAPABILITY

This practice's design is relatively simple, but with some outlet considerations that may limit their use. Generally, these are placed in depression areas that already contain erosive swales or gullies, which are damaging down-grade uses, such as roadways or other cropland fields. These waterways are generally easy to install in swales, but not as easy in severe gullies, which require multiple structures. Waterway and pipeline outlets need protection from high flows. Most dryland farms are capable of waterway installation and maintenance, but vegetative species may be limited by climatic factors, such as winter temperatures and soil water availability.

4.2.4.6 OPERATION AND MAINTENANCE CAPABILITY

As mentioned before, successful germination and lifespan of vegetation will determine how extensive maintenance will be. Care will need to be taken during any tillage or spraying operations, so that they are not damaged or reduced in area and effectiveness, which typically happens with tillage over many years. Protection from weed and insect damage is needed to ensure proper functioning during runoff events. Replacement of waterway vegetation is expected, depending on maintenance and climatic variables.

4.2.4.7 MONITORING AND VERIFICATION CAPABILITY

Verifying that a waterway is successful and functioning adequately is relatively easy. Quantifying a carbon levels may be also be simple, if adequate soil samples are taken and site inspections verify maintenance. It may be difficult to establish an exact level of carbon increase, however, if baseline data has not been generated similarly to what is required under a carbon market contract. In most cases, though, verification through soil sampling can establish baseline conditions for the first year of a contract. Those acres no longer being tilled would result in reduced nitrogen losses if fertilization is not longer occurring within the waterway.

4.2.4.8 ANCILLARY BENEFITS

With permanent, perennial vegetative cover within gullies and depression areas, most of the erosion from dryland crop fields is reduced, benefiting downgrade offsite areas, such as streams and roads. Some wildlife habitat may be improved as well. Water quality in surface and ground water bodies will also benefit from less soil movement and nutrient loss.

4.2.5 Nutrient Management

4.2.5.1 DESCRIPTION

The primary definition of nutrient management is the managing the amount, source, placement, form, and timing of the application of nutrients and soil amendments. See the NRCS standards web site http://www.id.nrcs.usda.gov/Engdwnld/construction_specs.html for further information on this practice.

Nitrous oxide (N_2O) from agriculture soils can constitute a large amount of agricultural greenhouse gas emissions. Agricultural lands contribute to N_2O emissions through the breakdown of nitrogen fertilizers, manure decomposition in soils, and releases from legumes. Emissions can be reduced by increasing efficiency of fertilizer use, including more precise fertilizer placement and timing, with immediate incorporation of fertilizers into soils.

Fertilizers, whether industrially synthesized or organic (like animal manure and leguminous plant residue), add nitrogen to soils. Any nitrogen not fully utilized by agricultural crops grown in these soils undergoes natural chemical and biological transformations that can produce nitrous oxide (N_2O), a greenhouse gas.

Scientific knowledge regarding the precise nature and extent of nitrous oxide production and emissions from soils is limited. Significant uncertainties exist regarding the agricultural practices, soil properties, climatic conditions, and biogenic processes that determine how much nitrogen various crops absorb, how much remains in soils after fertilizer application, and in what ways that remaining nitrogen evolves into nitrous oxide emissions.

At many sites, more fertilizer is applied than can be effectively used by crops. Further, poor fertilization timing or placement often leads to additional nitrogen loss or unavailability to the plant. One major reason for the application of excess nitrogen in the fields is the lack of simple field testing for nitrogen. Also, many farmers believe that some "excess" may be necessary to ensure peak production. This is because precise crop needs are not always known, and weather and climatic conditions that affect crop growth and nitrogen requirements are unpredictable.

Several fertilization management approaches and some other specific fertilizer technologies offer opportunities for enhancing nitrogen-use efficiency. Several may be integrated into alternative agricultural systems that incorporate lower fertilizer usage and also achieve energy savings by reducing the need for plowing and other energy intensive practices. Management approaches include:

- Improve fertilizer application rate,
- Improve fertilizer application timing,
- Improve fertilizer placement,
- Utilize split applications,
- Utilize GPS technology,
- Regular soil testing,
- Use fertilizer compounds with lower nitrogen content,
- Implement residue management,
- Use fertilizers with nitrification inhibitors,
- Use fertilizers with reduced water solubility coatings,
- Reduce use of fertilizers containing anhydrous ammonia,
- Incorporate nitrogen-fixing crops.

The costs associated with all of these alternatives vary needs further examination by the farmer, prior to selecting the most beneficial methods, which may be dependent on the operation.

4.2.5.2 EFFECTIVENESS

Currently, Idaho has about 4.5 million acres of cultivated cropland, 8.5% of the state's total land. Under current state regulations, all cropland acres with manure applied from dairies are mandated to implement nutrient management plans, applying manure according to agronomic rates (crop needs), not to exceed specific levels of nutrients within the soils, and considers water quality concerns. It is expected that eventually all croplands will be required to implement nutrient management. Currently, where federal and state funding is provided to land owners, nutrient management plans are required as well. Further analysis and research is needed to better estimate what each alternative may do in regards to reducing nitrogen losses as a gas.

While improved nutrient management provides multiple benefits, there is much uncertainty as to the amount of nitrogen loss that may be reduced from nutrient management, one estimate of from Lal et al, 1999, and other sources ranges from 0.05 to 0.8 MT CO_2e. For Idaho, an average amount of 0.3 MT CO_2e will be used to estimate a statewide potential.

Assuming that eventually all cultivated cropland acres will be under a nutrient management plan in the future, and assuming that even recent nutrient management plans have not caused any reasonable reductions in nitrogen loss, one may conclude that with 4.5 million acres, 1.4 MMT CO_2e could be achieved. A whole-farm analysis would need to be done to better estimate actual carbon credits available for purchase.

4.2.5.3 ACCEPTABILITY

Of the alternatives described above, fertilization rate, soil testing, and coated fertilizers may be the most widely adopted. Given good soil testing data, rates are more likely to be reduced when a good analysis is done by a certified lab and fertilizer company, if the company recommends lesser rates. Annual soil testing, if it will ultimately improve production and possibly show some net savings, may be adopted readily. However, depending on the crop type, annual soil testing may not be necessary if little or no fertilizer is to be used, such as with pasture or hayland. Coated fertilizers, if effective, are adopted if they do not cost much more than conventional types.

One aspect of nutrient management is that under a conservation plan, developed with state or federal agency assistance, includes this practice. Cost-share programs also require this practice to be implemented and carried out throughout the life of the contract. This practice will likely be applied to all cropland acres within the state through existing future state regulations.

4.2.5.4 COST

The time and inputs used to gain a certain amount of reduction in nitrogen may or may not prove a substantial net gain. Over time, given increased knowledge and experience on a particular farm, long-term costs may be lowered and less nitrogen loss occurring. A long-term farm analysis would be needed to estimate fully the costs of implementing this practice.

4.2.5.5 IMPLEMENTATION CAPABILITY

Some of the alternatives listed, such as soil testing, fertilizer types, and cover crops may not be readily acceptable or even available. Manufacturers must be providing these types of fertilizers to local companies to sell, and then farmers must be willing to pay more for some types. Planting cover crops may require more intensive management on the farmer's part, fitting in the planting within their normal late summer and fall work. There is usually no immediate return on the cover crop investment, but long-term in reduced pest problems, erosion losses, and other benefits. Some equipment is needed for better placement of fertilizers, which may or may be available to the farmer initially. A change in fertilization equipment may needed to achieve this practice.

4.2.5.6 OPERATION AND MAINTENANCE CAPABILITY

Upon adopting this practice and various alternatives, Operation and Maintenance Capability will likely be slightly more intensive. More soil testing to review, more records to keep, more or different equipment to maintain and understand, and a better understanding of fertilizer types will be important. A few years will be needed for a farmer to perfect the alternatives, while not likely seeing immediate results in soil fertility and net savings.

4.2.5.7 MONITORING AND VERIFICATION CAPABILITY

Intensive soil testing, record keeping and review, and other possible contractual requirements will be necessary to ensure that the nutrient management alternatives are being carried out properly. Monitoring costs can be excessive if allowed, making this practice not as a viable practice compared to others. Because there are really no visual aspects of this practice to check, except application method and timing, it will be difficult to verify that nutrient management indeed reduced nitrogen oxide losses.

4.2.5.8 ANCILLARY BENEFITS

Efficient fertilizer management may reduce nutrient runoff and leaching into surface and ground waters. Less fertilizer costs should occur, but may be offset by more soil testing, more expensive fertilizers, and time spent in record keeping. Measuring the physical benefits from an improvement in nutrient management is very difficult to measure, even at a research facility, therefore, actual benefits and costs are simply derived from simple expectations.

4.2.6 Windbreaks and Shelterbelts

4.2.6.1 DESCRIPTION

This practice is typically a linear planting of single or multiple rows of trees and or shrubs used to reduce wind velocities to reduce wind soil erosion, protect crop plants from wind related damage, manage snow deposition, shelter livestock and for recreational activities, and other uses. See the national NRCS web site for more information (http://www.ftw.nrcs.usda.gov/nhcp_2.html).

4.2.6.2 EFFECTIVENESS

These tree and shrub plantings are very effective in reducing wind velocity, but also provide long-term above and below ground carbon storage. Tillage practices are often used as an inexpensive method of weed control which may limit the amount of soil carbon storage. Longevity in windbreaks depend on maintenance, disease, extreme climatic conditions, and water availability. Irrigation waters are likely needed in semi-arid portions of the state for establishment and maintenance, which can effect the amount of carbon sequestration. Species types will also depend on climatic suitability and will effect the amount of sequestration. Windbreaks typically function effectively for 50 to 70 years and would continue to accumulate carbon over the life of the planting. Most of the windbreaks in the North Central U.S. were planted in the 1930’s in response to the dustbowl and most of these have reached the end of their functional life and are in need of replanting or rehabilitation.

In Idaho, if there were 22 thousand acres planted, and that for every 50 acres of land, there may be about 2 acres of land planted a windbreak (50 acres = 1476 ft^2), which is 50+ feet wide (= 4% of 50). If 15% all cropland fields maintained windbreaks or similar trees and shrubs, it may sequester nearly 0.3 MMT CO_2/ac/y. A whole-farm analysis would need to be done to better estimate actual carbon credits available for purchase.

4.2.6.3 ACCEPTABILITY

Many land owners in windy areas of the state are adopting windbreaks for wind erosion control and aesthetics. Dairies and feedlots also are utilizing these windbreaks for odor control and aesthetics. Along highly productive cropland fields, these windbreaks are not as acceptable, where wind erosion is not such a problem or can be solved with specific tillage alternatives, where there would be a loss of productive acreage.

4.2.6.4 COST

The cost of installation is expensive, especially in multi-row windbreaks. In semi-arid are of the state, irrigation is necessary for establishment and maintenance of the vegetative species. The carbon sequestered from most any type of woody species may be adequate to offset installation and maintenance costs if such a market exists. Soil stored within the above-ground biomass, roots, and soils within the windbreak area when not disturbed with tillage, may be a viable for credit amount to encourage additional practice installation throughout the state.

4.2.6.5 IMPLEMENTATION CAPABILITY

Semi-arid areas of the state would require irrigation of trees and shrubs for establishment and maintenance of windbreak. The water amount, its application costs, whether pumped from ground or surface water, or applied through gravity systems, and the time required for application may be considered additional time and money spent on little or no monetary return to a landowner that previous may have been seeing some return on investment on that productive portion of cropland. Some dryland areas may support this practice, but again, will depend on water availability.

4.2.6.6 OPERATION AND MAINTENANCE CAPABILITY

Upon establishment, minimal effort and time should be needed for maintenance, except when irrigation water is needed. Depending on the irrigation system, the time involved may still be minimal. Disease and weed control is very important and periodic inspections of windbreak and surrounding area should take place annually.

4.2.6.7 MONITORING AND VERIFICATION CAPABILITY

Determining if a windbreak is healthy and growing adequately should be relatively easy. Measuring annual carbon sequestration may not be feasible, where costs may be inhibitive. Periodic data collection, such as every 5 years, may be effective in understanding the rates of sequestration. A good understanding of the species and its capability of carbon storage may allow for modeling, which may be suitable for a carbon market. Annual inspections of windbreak health and maintenance should be completed, regardless of program.

4.2.6.8 ANCILLARY BENEFITS

These windbreaks reduce evaporation and plant transpiration rates such that per field crop yields are typically improved, even though a portion of the field has been converted to windbreaks (Kort and Turlock, 1999). These yield increases, along with reduced input costs, more than economically justify planting a portion of the land to trees, however, windbreaks are a long-term investment that can take 7 to 10 years to become fully effective (Brandle et al. 2000). Wildlife habitat is also enhanced with this practice.

4.2.7 Short Rotation Woody Crops

4.2.7.1 DESCRIPTION

Low prices for traditional crops have increased the interest of farmers in fast-growing woody crops, like hybrid cottonwood trees, for fuel and fiber. These trees can be planted in large blocks and provide a way of increasing on-farm income, while also being designed to accept agricultural, livestock, community, and industrial waste applications.

4.2.7.2 EFFECTIVENESS

Poplar plantations have many environmentally desirable applications, including use as buffer strips to decrease erosion and nitrate in runoff from highly erodible fields, for treatment and removal of toxic materials from landfills and other soil contaminations, and as an excellent sink of atmospheric CO_2. The rapid growth of these crops results in high rates of nutrient uptake and large amounts of carbon storage over rotation lengths as short as 5-15 years. Hybrid poplars could store carbon in woody biomass up to a 50-year period until primary production is offset by respiration and decay. As a long-term strategy, trees could be used as heating fuel for livestock buildings, home heating or corn drying, reducing propane or LPG consumption. Poplar trees would provide a similar carbon sequestration rate, but as a monoculture, they would be better managed as a renewable energy crop. A poplar tree buffer strip at Amana, established in 1988 by The University of Iowa, has produced 7.5 tons of dry matter per year after the third season.

If approximately 1 to 2 percent of all cropland converted to short rotation woody crops, for whatever purpose, there could be 0.56 MMT CO_2/y sequestered. A whole-farm analysis would need to be done to better estimate actual carbon credits available for purchase.

4.2.7.3 ACCEPTABILITY

As similar to conservation buffers and windbreaks, there would be replacement of cropland with long-term woody crops. However, this crop would take larger tracts of land, likely entire fields, for effective management and adequate net returns on the investment.

4.2.7.4 COST

While it seems there a substantial sequestration of carbon in woody biomass from poplar trees, switching to a long-term crop means eliminating the annual income from an annual crop. Therefore, farmers would need to adjust to larger payments, but fewer of them. Initial investments may not justify adopting this crop where the operation has been funded through annual harvest of crops and market prices. It is most likely that if such a market exists for a long-term crop, though a short period of growth for woody species, landowners would be more open to substituting annual crops with short-rotation woody species if the guarantee of payment is there. If irrigation water is continued to be used, the costs may not be recaptured until harvest, some years later.

4.2.7.5 IMPLEMENTATION CAPABILITY

There must be a market for these short-rotation woody crops. Local markets and infrastructure must be available and viable to process the biomass produced on small or large tracts of land, from multiple landowners. Harvest and transportation mechanisms must be in place so that the market for these crops is sustainable. Landowners will need the finances to establish this crop, while not likely receiving any return for at least 10 years until harvest. Adjustments in the typical crop management will need to take place, which include fertilization, pest control, and watering if in semi-arid parts of the state. Long-term contracts may not be as acceptable, or may, with landowners where if a crop failure occurs, replacement will be expensive.

4.2.7.6 OPERATION AND MAINTENANCE CAPABILITY

The trees can re-sprout (coppice) if allowed so there may be no need for replanting unless required by market demands. Replanting may be necessary to maintain some level of genetic purity. Harvesting equipment would need to be available, along with narrower light tillage equipment if other non-tillage, herbicide based weed control is difficult or restricted with woody crops. Adequate fertilizer and water needs will need to be met to ensure a minimum level of growth and sequestration. Some pruning may be needed if for a specific production.

4.2.7.7 MONITORING AND VERIFICATION CAPABILITY

Annual inspections of growth and health will likely take place if there is a market contract in place. Land owner and operator management will likely be more intensive to ensure a good return on investment, which with record keeping, may provide a greater amount of certainty of verification.

4.2.7.8 ANCILLARY BENEFITS

Planting trees within agricultural lands will benefit water quality, soil, groundwater, and wildlife habitat, while sequestering carbon dioxide in woody biomass. Poplar plantations have many environmentally desirable applications, including use as buffer strips to decrease erosion and nitrate in runoff from highly erodible fields, for treatment and removal of toxic materials from landfills and other soil contaminations, and as an excellent sink of atmospheric CO_2. Gasified poplar biomass could also be used as heating fuel for livestock buildings, home heating or corn drying (reduces propane or LPG consumption).

4.2.8 Crop Residue Alternative Uses

4.2.8.1 DESCRIPTION

Where there is open burning associated with agricultural practices, a number of greenhouse gases (GHGs) are emitted from combustion. All burning of biomass produces substantial CO_2 emissions, however, the CO_2 released is not considered to be net emission. The biomass burned is generally replaced by regrowth over the subsequent year. An equivalent amount of carbon is removed from the atmosphere during this regrowth, to offset the total carbon released from combustion. Therefore the long term net emissions of CO_2 may be considered zero. Agricultural burning releases other gases in addition to CO_2 which are by-products of incomplete combustion: methane, carbon monoxide, nitrous oxide, and oxides of nitrogen, among others. These non-CO_2 trace gas emissions from biomass burning are net transfers from the biosphere to the atmosphere. The majority of cropland related burning in Idaho comes from bluegrass and wheat stubble.

The potential usefulness of agricultural waste or residue could include composting, alternative (biomass) fuels, livestock feed supplements, substitution for paper or wood products, or building materials. Such applications require the mechanical removal of residues from the field. While compliance with some commodity support programs may prohibit this removal, if no conflicts or restrictions exist the crop residues can be used and marketed in a variety of ways.

Composting involves gathering agricultural wastes and setting them aside to decompose. Residue collection methods with this application include raking, residue flail-chopping, and vacuuming into sacks with soil and nitrogen sources such as chicken manure, and crew-cutting. After the waste has decomposed, the decayed material can either be marketed or returned to the soil as fertilizer. Composting can be relatively time-consuming compared to burning. The level of effort necessary for a productive program depends on several factors, including decomposition rates and weather and moisture conditions. Also, the process of large-scale composting is not fully understood or refined. The Agricultural Research Service (ARS) in Corvallis, Oregon, is researching the effectiveness of low-input composting and ideal composting procedures.

Agricultural crop wastes such as grass straw can be collected and sold in a supplemental feed market. The straw must be gathered, baled, stored, and compressed so that it can be shipped on order. This practice is currently one of Oregon's primary alternatives to burning. Approximately 150,000 - 250,00 tons of straw are shipped to Japan each year (Britton, 1992). Untreated straw makes for poor quality livestock feed because of low protein and high fiber content. With appropriate treatment (*e.g.*, ammoniation), the digestibility and palatability of straw can be increased substantially, making straw a potential component of maintenance diets for ruminant livestock.

Residues can also be gathered for fiber or building materials. The University of Illinois has been studying the fiber quality and chemical composition of corn stalks and corncobs grown in Illinois and the potential of agricultural waste fibers in producing composite construction materials. Studies on fiber properties showed that corn stems (core and outer layer in general) are a promising substitute for traditional fiber sources (Chow, et. al., 1997). Weyerhauser, a paper and lumber company, is investigating the possibility of using agricultural residues as filler in particle boards.

4.2.8.2 EFFECTIVENESS

Most alternatives that eliminates burning should provide some greenhouse emission reductions (CH_4, CO, N_2O, NOx). However, the selected alternatives, such as harvesting those crop residues that would have been burnt, may have additional equipment usage associated with it that may increase nitrous oxide emissions from the farm. Any additional equipment usage that wouldn't have normally occurred under the current burning operation, may in fact offset a portion of the emissions no longer being released through burning. Net emissions need to be calculated to determine if this practice is a viable alternative.

To calculate what amount of emissions may be reduced, depends on the amount currently lost due to burning, with its use considered after. Factors used in determining emissions are:

- Amount of crops produced with residues that are commonly burned;
- Ratio of residue to crop product;
- Fraction of residue burned;
- Dry matter content of residue;
- Fraction oxidized in burning; and
- Carbon content of the residue.

Idaho has approximately 1.2 million acres of wheat (Ag statistics 2001 data), 670,000 acres of barley, and about 35,000 acres of bluegrass. If 150,000 acres of wheat, barley, and bluegrass are burned annually (12.5% of those crops), and all burning was eliminated, total net emission reductions could be nearly 0.5 MMT CO_2e/y. This estimate is simply looking at annual net emissions derived from burning. It does not factor in long-term benefit or what change in cropland residue management may occur following a no-burn situation. A whole-farm analysis would be needed to estimate actual net reductions in emissions, where alternatives would likely increase fossil fuel use for residue collection, transportation, and production. Depending on its ultimate use, net reduction in emissions will vary. The equation used to estimate the potential can be found in Appendix 7.

4.2.8.3 ACCEPTABILITY

It is much less expensive to burn excess residues than to operate equipment to collect and transport residues for other uses. If residue were incorporated into soils, additional tillage would be needed, which may not be acceptable. Where technology has not completely satisfied operators with effective alternatives to burning, it is likely that burning will continue to be the most economical and successful alternative for production, especially for bluegrass. Air quality regulations will likely cause farmers to further evaluate alternatives to burning rather than a climate change program or carbon market, unless, of course, incentives are large enough.

4.2.8.4 COST

With the amount of national emissions being contributed to agricultural burning is very low, the global benefits to reducing burning may also be low. The costs involved with adopting a practice that no longer involves residue burning will likely be higher and the net benefit to the farmer from adopting this practice is not yet well known. There may likely be some production loss in the case of bluegrass production, but the market demand may be offset by increasing acres of this crop. Regardless of the alternative, initial costs to the producer will increase.

4.2.8.5 IMPLEMENTATION CAPABILITY

Switching to a no-burning alternative may not be easily implemented, especially if the residues are collected for alternative uses. Marketing these residues in Idaho or anywhere within the United States may be more difficult than in foreign markets due to the erratic and competitive nature of U.S. markets. Combustion for heat generation may be the most appropriate means of replacing fuel oil with residues, because much less investment is necessary compared to replacing fuel oil in power generation. Also, the total maximum efficiency of the power produced by means of a turbine or steam engine is approximately 15 percent, even though the combustion of biomass can be accomplished with high efficiency (Strehler and Stützle, 1987). The disadvantages of gasifiers include a high particulate and tar content of the gas. Furthermore, current gasifier designs do not accept all types of crop residues. Finally, after biomass burns, a silicate remains, creating a sludge problem that inhibits acceptance of residues as an alternative fuel.

When considering residues as alternative sources for paper and fiber products, major retooling in the wood fiber industry may be needed because wood chips do not require storage from rainy weather, whereas residues would need protection from the climate during storage. Despite this, however, grass straw is becoming a more economically attractive alternative to using hardwoods. The reason for this is the projected shortage of hardwoods in the near future and the fact that straw fibers from grass seeds are very similar in structure to hardwoods.

4.2.8.6 OPERATION AND MAINTENANCE CAPABILITY

Tillage and residue collection activities will change how the farmer operates. If there is no source demanding the residues, then significant changes in tillage practices will occur to deal with the residue.. As with any new operation and facilities, there will be substantial oversight to ensure that it is functioning properly and meeting its objectives. There will increased costs to the operator that will need to be offset by the sale of its product, possibly coming in the form of incentives from government or other carbon market participants.

4.2.8.7 MONITORING AND VERIFICATION CAPABILITY

Depending on the selected alternative here, continual monitoring to ensure operation and maintenance is occurring properly is foremost. Verification of actual emissions reductions may be estimated by the elimination or reduced level of residue burning. A quantity of emissions reduced on a per acre bases may be used primarily in conjunction with monitoring to calculate an actual emission reduction, sellable through a carbon market. Specific requirements for monitoring are likely to ensure that estimated emission reductions are occurring. Verification will likely not occur frequently due to costs and its research-like process. Satellite or aerial photography may be a feasible method of tracking its implementation. Monitoring the use of the residue will be addressed in the bioenergy section.

4.2.8.8 ANCILLARY BENEFITS

Fewer air quality concerns and complaints, actual emission reductions through less burning, higher facility and equipment operation costs and time input, reduced potential soil erosion on burnt land, and other benefits and costs may occur. Further research and analysis is needed for each alternative to better understand costs and benefits. If residues are used for co-fired energy or long-term products, then additional benefit may be known. Health issues would also be resolved with this practice.

4.2.9 Alternative Burning Techniques

4.2.9.1 DESCRIPTION

A number of alternatives that still involve burning might reduce emissions. This can be accomplished, for example, either by creating a hotter, more controlled burn that combusts crop residues more thoroughly, or by reducing the frequency of burning in conjunction with mechanical crop removal techniques. Technologies and methodologies to achieve these objectives include mobile field sanitizers, propane flaming, bale/stack burning, reduced burning and crewcut-vacuum sweeping. Further research is needed to truly identify those alternatives that are certain to reduce emissions generated from burning. Eliminating or reducing burning might reduce daily greenhouse gas emissions but the long-term benefit is not yet fully apparent. Other alternatives are being studies and may provide better alternatives than these below.

Mobile Field Sanitizer. This is a machine designed to burn agricultural residues in place. It serves as a method of both straw removal and field sanitation.

Propane Flaming. Propane flamers consist of a propane tank and a series of nozzles. The propane is released, ignited, and directed at ground level. Because straw residue must be removed first for this method to be effective, this technique is typically used with other disposal methods such as bale/stack burning.

Bale/Stack Burning. Bale/stack burning, the collection of crop residues into bales or stacks to facilitate controlled burning, is a companion practice to propane flaming (which requires straw removal). Some growers have turned to bale/stack burning to dispose of unmarketable crop residues.

Reduced Burning. This involves alternating open field burning with various methods of mechanical removal techniques. Reduced burning would involve burning every second or third year instead of annually.

Crewcut-vacuum sweeping. University of Idaho researchers have conducting production research under a system that does not include burning of post-harvest residues, but mechanical residue removal systems. Seed yields in bluegrass seed production ranged from 400 to 1000 lbs/ac under this mechanical system, which results in similar yields under burning systems. This is a promising alternative to burning which would reduce emissions.

4.2.9.2 EFFECTIVENESS

There are uncertainties regarding net impact on greenhouse gas emissions from each of these alternatives, as well as crop residue burning. While field tests have shown that sanitizers can reduce carbon monoxide and hydrocarbon emissions, their applicability appears limited. While propane flaming are thought to bring about a slight reduction in emissions when used together, they are much more time consuming than open field burning. If most of the straw residue is removed prior to flaming, this technique should not result in major seed yield losses. Bale/stack burning may result in slight reductions in emissions, but is more time consuming than open field burning.

These alternatives to burning would yield similar reductions in emissions as would the non-burning alternative uses of residues, except, these residues may or may not be removed physically from field, which then could be used for further biomass power generation or other uses. If reduced burning to every 2nd or 3rd year, then emission reductions would be reduced respectively. Eliminating burning, such as discussed within the alternative residue uses above, might provide the greatest emission reductions, but depends on its use. These alternatives may reduce daily greenhouse emissions, but it is not clear on long-term benefits.

4.2.9.3 ACCEPTABILITY

Developing or purchasing field sanitizers and propane flamers, as well as stockpiling excess residues, have high costs that may not be feasible. The uncertainties of these methods on their effects of crop production (as with bluegrass seed) and actual net emission reductions may keep the acceptance level low. Adoption of any practice by a farmer or even other carbon market participants looking to offset their emissions will be limited to the available data regarding their impacts. To the farmer, little or no loss in production and greater net returns are to be confidently expected prior adoption. The buyer of carbon credits must be certain that the practices are going be effective, delivering what has been promised through research and confidence in the seller. The expectation of these practices being widely adopted is low due to the uncertainties and high costs.

4.2.9.4 COST

Technical and economic evaluations of field sanitizers have found problems with high operating costs, durability, maneuverability, energy use, and operating speed. Based on these studies, many states have discontinued research and development of mobile field sanitizers, although there has been some success with their private development.

Where high value crops exist, propane flaming may be found economical to develop and maintain the sanitizer. However, typically, the high costs associated with development frequently prevent other farmers from pursuing this option.

4.2.9.5 IMPLEMENTATION CAPABILITY

There are a number of uncertainties that limit the applicability of some alternative burning techniques. For example, mobile field sanitizers have not been fully developed and have proven successful only in isolated cases. The technical problems associated with field sanitizers mentioned above need to be addressed before widespread acceptance of this option can be expected. Similarly, improvements in techniques like propane flaming may be required to make it an attractive alternative. For example, studies have shown that because of the temperature and duration of propane flaming, many of the weed seeds are not destroyed, ultimately resulting in increased weed infestation (U.S. EPA, 1992b). Moreover, the fossil energy inputs required for these techniques emit greenhouse gases, so the net effect on emissions is not clear. These problems will need to be addressed in order to facilitate acceptance of these alternatives.

4.2.9.6 OPERATION AND MAINTENANCE CAPABILITY

With additional equipment there comes additional operation time and maintenance, thus greater costs. There would also be a greater emphasis on operation and its procedures to ensure successful crop production, while not burning with the same technique used for decades. There will be a great of amount of self education required by each farmer adopting these practices, before and during operation.

4.2.9.7 MONITORING AND VERIFICATION CAPABILITY

Record keeping on operation times and location, which would coincide with the crop rotation, will provide most of the information necessary to ensure emission reductions are to occur. Field verification periodically upon operation completion may occur to ensure compliance while under a contract. Remote sensing may also provide for monitoring. Actual verification of emission reductions may be very limited due to costs and its research oriented procedures.

4.2.9.8 ANCILLARY BENEFITS

Less burning will provide for cleaner air during periods that burning typically occurred. Fewer citizen complaints and lawsuits should occur as well. Costs of operation will likely rise which could be offset within a carbon market. Better ground cover with alternative perennial crops, primarily during the winter months, can reduce soil erosion, thus improving the quality of local water bodies.

4.3 RIPARIAN/WETLAND AREA ACTIVITIES

4.3.1 Riparian Forest Buffers

4.3.1.1 DESCRIPTION

These buffers are largely areas consisting predominantly of trees and/or shrubs located adjacent to and up-gradient from watercourses or water bodies, usually associated with croplands and pastureland. Rangelands, forest lands or other those lands not as effected by farming practices, would most likely be addressed by riparian conservation/restoration practices, discussed later. Where windbreaks are designed to reduce wind velocities and odor, these buffers are likely more diverse in species types and planting arrangements. These buffers are meant to help improve stream-side riparian conditions, filter upland runoff to water bodies, and provide in-stream benefits, such as cooler temperatures and riparian area habitat diversity. These buffers would not be planted within the water body itself, as would the channel vegetation practice.

4.3.1.2 EFFECTIVENESS

Where woody vegetative species are planted and maintained for long periods of time, carbon storage is certainly to increase. Diversity in buffer strip vegetation is beneficial for natural succession and health. Above-ground biomass and root carbon storage will depend on vegetative species types. Further research is needed to better quantify the effectiveness or these buffers, primarily their effect on soil carbon.

However, with some preliminary estimates on forested, above-ground biomass, some estimate of sequestration may be made. There are approximately 70,000 miles of perennial streams in Idaho, associated with private and state lands. Some of these streams are actually artificial drainages which may have been naturally intermittent or perennial, but altered in shape and flow. These are usually found within private irrigated areas (derived from GIS shapefile query with idown.shp and hydro100.shp, found at http://www.idwr.state.id.us/ftp/gisdata/shapefiles/statewid/).

If riparian buffers consist of about 6 acres per mile of length, and 1 to 2% of available croplands installed buffers, then this amount of newly forested land would sequester about 49,000 MT CO_2/y. A whole-farm analysis would need to be done to better estimate actual carbon credits available for purchase.

4.3.1.3 ACCEPTABILITY

Where riparian areas are continually grazed or used for other purposes, buffer strips are not as likely to be adopted without assurance that the existing use may continue. Buffer strips, installed through cost-share programs, usually require some or complete protection during establishment, possibly throughout its lifespan. Woody species may reduce the amount of herbaceous grass-like riparian species once shading has increased, which may not be considered a benefit for livestock grazing. Other benefits of riparian health that can come from buffers may be realized through increased wildlife and fisheries populations, though not easily accounted for. Where irrigation waters and diversions are a part of the water corridor, drainage districts, irrigation companies, and private landowners may have some maintenance rights and continual activities that may not be suitable for buffer installation. Within forested areas, the Forest Practices Act requires some buffering along riparian areas, therefore, acceptance here may not be a factor.

4.3.1.4 COST

Installation costs are relatively high, depending on species types, density, and availability. If adequate surface and ground water is available, then establishment and maintenance should require less input and replacement may be less. Fencing may be required where grazing has been occurring, which may increase installation and maintenance costs. The amount of carbon sequestration may offset these costs if the market exists.

4.3.1.5 IMPLEMENTATION CAPABILITY

Climatic conditions, drought tolerance, perennial flows, grazing and other uses, installation and maintenance costs and other factors would likely be considered barriers to implementation of riparian buffers. Any potential loss of existing use would likely be considered a negative aspect to a landowner. Establishment costs may be prohibitive where a quantity of vegetative species water availability is limited. Fencing exclosures, if required, would likely not be acceptable to most ranchers, as there an additional maintenance burden and may be considered a permanent loss of riparian use.

4.3.1.6 OPERATION AND MAINTENANCE CAPABILITY

Upon establishment of vegetative species and appurtenances, such as fencing, operation is likely rather simple, but maintenance will ongoing, especially within areas with highly reoccurring fire hazard. Fire prevention, such as thinning and annual grass and weed control may need to take place. Fencing, if a required component, would be maintained to ensure no or limited access by livestock. Where grazing is allowed or some other use, restrictions are likely to be in place, requiring the landowner further inspections and a higher level of management to ensure vegetative species health. Soils would need to be protected for minimal erosion and compaction as well.

4.3.1.7 MONITORING AND VERIFICATION CAPABILITY

Annual inspections would likely be necessary to ensure vegetative species health. Water body and flood area stability would need to be evaluated to determine if flood waters would cause excessive erosion or harm to vegetation. Some periodic soil and vegetation carbon analysis may be necessary to ensure sequestration is taking place at a given rate or expected quantity, specified within a contract. Fencing and grazing management records may need to be inspected to ensure maintenance is taking place as prescribed within a contract between parties.

4.3.1.8 ANCILLARY BENEFITS

Tree growth is accelerated in riparian zones due to favorable moisture and nutrient conditions. When buffer trees, shrubs, and grasses are designed and planted in these moist environments they can also filter out excess nutrients, pesticides, animal wastes, and sediments coming from upland activities. Wildlife habitat is greater enhanced, for multiple species, depending on vegetative species and management.

4.3.2 Riparian conservation/restoration

4.3.2.1 DESCRIPTION

This practice includes management that enhances, preserves or restores stream-side vegetation. Typically, this practice is implemented to improve stream bank protection and increase flood zone areas. This helps prevent erosion and siltation of the streams, and maintains habitat for fish and wildlife. Since the effort promotes vegetative growth, it provides an opportunity for carbon sequestration.

4.3.2.2 EFFECTIVENESS

Riparian areas benefit greatly from increased woody vegetation, if in the proper setting. Some riparian areas are not suitable for long-term production of woody species due to anaerobic conditions caused by flat valley bottoms, sinuous stream channels, and low gradients, such as with natural wetlands. Where found appropriate for long-term growth and natural regeneration, riparian areas could provide additional carbon sequestration.

Similar to riparian buffers, some preliminary estimates on forested land carbon sequestration may be made. The difference between buffers and this practice is that riparian areas may continue to be grazed. With prescribed grazing practices, riparian vegetation may be kept at a particular threshold, such as a 50/50 combination of grass (forage) and trees (mainly riparian shrubs). With there being approximately 70,000 miles or less of private and state land perennial streams in Idaho then an estimate of carbon sequestered within riparian areas can be made. If the average width of the entire riparian area (both sides of stream) is nearly 70 feet, then a riparian conservation system per mile may consist of 9 acres. If up to 35% those private and state riparian lands a riparian conservation project, then there could be up to about 0.3 MT CO_2/y. If public lands were included, this amount would increase substantially. A whole-project area analysis would need to be done to better estimate actual carbon credits available for purchase.

4.3.2.3 ACCEPTABILITY

Many streams in Idaho are on public land or are not easily reached. Unless initiated by the landowner, a large amount of riparian plantings for additional carbon storage will not likely occur. Riparian areas utilized by livestock are not as likely to be planted to achieve increased woody species. Where riparian areas are used for recreation, then areas may be more susceptible for actual plantings, where the public are more aware of the existing conditions. Non-planting riparian improvements may likely occur more frequently in areas not easily reached.

Some riparian areas within irrigated portions of the state have been altered for irrigation drainage purposes and are within a drainage district or canal company jurisdiction, which enables channel cleaning.

These areas are not likely going to be planted with woody species or allow for intensive riparian conservation due to existing maintenance procedures.

4.3.2.4 COST

The benefits in increasing or changing from one herbaceous, grass-like vegetative species to a woody species would increase carbon storage, primarily in biomass. Ancillary benefits, if used in cost analysis, would hopefully return high. Costs of planting, additional fencing components, livestock watering facilities, and other measures to ensure long-term growth and protection would initially be high. Thus low acceptability by landowners. However, if long-term analysis is used, looking into future benefits, such as aesthetics, increased wildlife, reduced pressures from outside interests in protection of riparian areas, should outweigh initial costs, especially if cost-share programs or incentive payments are provided to assist in the implementation of this practice. Maintenance and operation costs would need to be expected to effectively assess cost in the long-term.

4.3.2.5 IMPLEMENTATION CAPABILITY

With natural perennial stream areas, riparian improvements are more likely achievable. Water availability is absolutely necessary, over long periods of time, for carbon sequestration and storage to continue. If beaver activity subsides due to trapping or other natural reasons, beaver dams are going to eventually fail, lowering the adjacent water table, then no longer available to young woody species necessary for natural regeneration. The woody species would eventually be replaced with non-hydrophytic upland species, while the active floodplain much more narrow, reducing the quantity of woody species.

Cost-share programs, easements, continuous payment programs (such as continuous signup CRP) are needed to encourage landowners to improve riparian areas. Some landowners, however, do improve riparian areas with woody species for various reasons, such as aesthetics and wildlife. Given a purpose and the funding, landowners may adopt this practice is maintenance requirements is low. In areas with natural regeneration capability, there may be easier implementation.

4.3.2.6 OPERATION AND MAINTENANCE CAPABILITY

If water availability is fairly constant, riparian woody vegetation can be maintained. Where livestock use is eliminated, there will generally be a natural succession to mature woody species, unless soil conditions are super-saturated. Maintenance of riparian areas may be dictated by a contractual agreement, consisting of a specified level of carbon flux or ultimate storage. Fire management tools, livestock grazing, and other practices may be utilized to ensure a minimum rate of carbon flux, but care will need to be taken so that excessive utilization of vegetation does not occur.

4.3.2.7 MONITORING AND VERIFICATION CAPABILITY

Periodic inspections of riparian areas will be needed to ensure good management is occurring and that woody species are vigorous and regenerating. Annual grass species, weeds, insects, and disease will need to be looked for to prevent excessive damage or loss to the desired species. Floodplain management will also need to occur through proper streambank protection and conservation of vegetative species. Records would likely need to be kept on livestock and other uses to ensure long-term maintenance is occurring.

Actual verification of carbon sequestration may be difficult, even if monitoring is completed. Measuring tree growth within non-shaded, highly wet, riparian areas may be difficult compared to a forest setting where shrub-like species will generally dominate, making it difficult to estimate the quantity of biomass.

4.3.2.8 ANCILLARY BENEFITS

Enhanced wildlife habitat, aquatic habitat, bio-diversity, streambank stability, aesthetics and other benefits are realized through riparian improvements. Social pressure on land users and mangers may also be realized with ongoing and progressive riparian improvements and maintenance. Within state lands, there could be additional areas for recreation, possibly on private lands if authorized by the landowner.

4.3.3 Constructed or Restored Wetlands

4.3.3.1 DESCRIPTION

These wetlands, whether artificially developed or restored back to its natural state, can provide hydrophytic vegetation that can sequester carbon. Constructed wetlands are primarily built for water quality treatment. A restored wetland is simply within an area once a natural wetland, having been drained for other purposes, converted back to its pre-developed state.

4.3.3.2 EFFECTIVENESS

The effectiveness of a wetland in sequestering carbon in the vegetation and hydric soils, will be variable, depending on species, soils, climatic area, and management. With constructed wetlands, they may not always be operated year-round, where maintenance may be required to keep its capacity and vegetation within a specific age class. There are likely more water fluctuations in constructed than with a natural wetland because of their purpose, where storm and irrigation wastewater runoff is generally treated. Further research will be needed to determine general carbon sequestration effectiveness.

Ogden 2001 examined the potential effectiveness of waste treatment constructed wetlands and though the carbon cycle is extremely complex and rates of net carbon retention or sequestration are difficult to measure, he submitted a formula to estimate rates for wetlands in south eastern US. states. For a 9-10 acre wetland, treating about 1 million gallons a day (MGD) of effluent, would sequester about 0.35 MT/acre/yr. Ogden does discuss the uncertainties and further research needed to better estimate rates. Nitrogen availability and metabolic activity are such variables.

If Idaho were to install and maintain 7,500 acres of wetlands in the state, then 2,625 MT CO_2/y could be sequestered. A whole-project analysis would need to be done to better estimate actual carbon credits available for purchase.

4.3.3.3 ACCEPTABILITY

The type of wetland and the area it may be developed in may be a factor in its acceptability. In irrigated areas of the state, irrigation districts and canal companies are becoming more acceptable of the constructed wetlands to treat waste water runoff, prior to it entering water bodies. This acceptance is largely due to the potential of future regulation under the Clean Water Act, which impacts water quality improvements in both point and nonpoint source activities. Natural wetlands that were drained for other purposes, such as cropland or urban development, may not be converted back to its pre-development state very easily, especially those under urban development. If very little structural work is needed to convert it a wetland once again, then there may likely be a higher acceptance level, if the current land use profits are offset. Wildlife and other benefits may be enough to convince some landowners to revert the land back into its pre-development state. With the recent outbreak of the West Nile Virus, landowners wishing to install these wetlands may face community resistance.

4.3.3.4 COST

These constructed wetlands are generally very expensive to install, generally in the millions of dollars for large systems. If few structural modifications are needed to build or convert land into a wetland, then the cost should be much lower. Without knowing site-specific information and having a design in hand, construction, operation, and maintenance costs are unknown.

4.3.3.5 IMPLEMENTATION CAPABILITY

There may not be many constraints to building or restoring a wetland in soils and climates that are already suitable. Building a new wetland where soils are not suitable to hold water, such as in sandy soils, there would be a great cost to line the bottom of the holding ponds. Adjacent lands, possibly not owned by the same owner, may be impacted by raised water tables because of a new wetland. Engineers usually determine water tables and a wetland's impact on surrounding areas, so there may be enough information to keep the wetland from being built. If a new wetland has been built, and neighboring lands are becoming wet, there will likely be complaints and legal action to ratify the situation.

4.3.3.6 OPERATION AND MAINTENANCE CAPABILITY

With any new practice, there comes additional operation and maintenance. Constructed wetlands are certainly a practice that requires annual maintenance, and a good understanding of its operation to perform as designed. Natural wetlands should not require much maintenance, accept repairs due to storm or flood events. If a certain climax vegetative community is to be maintained, then maintenance may be increased where vegetative species are replaced to re-start the natural succession of species. Excessive soils and vegetative growth may need removed periodically to ensure that the wetland is functioning according to its design.

4.3.3.7 MONITORING AND VERIFICATION CAPABILITY

Constructed wetlands inflows and outflows are measurable because the are usually designed for such activity. Measuring for sequestration may nearly impossibly except with intensive research methods, which would likely be cost-prohibitive. Verifying that sequestration actually occurred for a period of time may only be feasibly based on typical rates of carbon flux per species. A wetland could easily be inspected annually to ensure that operation and maintenance is occurring.

4.3.3.8 ANCILLARY BENEFITS

Waterfowl, wildlife, water quality, and other natural resource improvements can be achieved with wetlands. Increased waterfowl may be hunted near and around the wetlands, which may increase the landowner's profit margin, and provide funds for operation and maintenance. Where constructed wetlands are installed, operators that treat upland land user's waste waters may, if legally capable, charge annual maintenance fees to offset costs of operating the wetland. The property in which the wetland is built may have tax incentives or property tax adjustments which may increase or decrease property values.

4.4 GRAZING LAND ACTIVITIES

4.4.1 Prescribed Grazing

4.4.1.1 DESCRIPTION

This is a practice of a controlled harvest of vegetation with grazing or browsing animals, managed with the intent to achieve a specified objective, such as weight gain for beef cattle and weight and health maintenance of dairy cattle. In regards to carbon sequestration, improvements of vegetative stands or seeking additional diversity of species may be the objective, which may increase below-ground carbon storage (soils, roots). See the Idaho NRCS web site for additional information on this practice: http://www.id.nrcs.usda.gov/Engdwnld/construction_specs.html.

4.4.1.2 EFFECTIVENESS

The conversion, restoration, and management of U.S. grazing lands, including pasture and range, are estimated by one source to have an additional total carbon sequestration potential of about 29.5 to 110 MMT per year with improved management practices accounting for much of that potential. After accounting for carbon losses from grazing lands they are estimated by that source to have a net potential of sequestering about 17.5 to 90.5 MMT annually (Follett et. al., 2001). This compares to 123 to 295 MMT for cropland soil sequestration and fossil fuel offset / emission reduction potential. However, grazing land potential sequestration figures are still subject to discussion.

Recent research conducted in Kansas's grasslands, however, indicates that for most or normal grazed or ungrazed grasslands the net carbon flux is zero. That source indicated that grazing lands aren't generally accumulating carbon and that the only way sequestration is likely to occur on a given pasture is if it has been abused and land management is changed. Given current research, some caution seems in order when considering carbon sequestration potential on grazing land.

Schuman et al. 1999 showed that well managed grazing of mixed grasses on rangelands may increase carbon storage by 0.13 tons, compared to non-grazed exclosures. This evidence needs explored further to better estimate carbon sequestration and ancillary benefits.

Idaho has about 4.9 million acres of rangeland and pastureland, in which prescribed grazing could be implemented. If 50% to 75% of those private and state lands were in poor condition, and this practice was implemented, then up to 0.67 MMT CO_2/y could be sequestered after conditions became good. A whole-ranch analysis would need to be done to better estimate actual carbon credits available for purchase.

4.4.1.3 ACCEPTABILITY

Where improved grazing management is seen as a benefit to a livestock operation, primarily in weight gain and health, this practice may be well accepted. This practice is prescribed, however, on rate and physiological conditions of plant growth, which will set vegetative use in amounts and timing. Depending on available soil water and climatic conditions, this practice may be difficult to meet when livestock numbers are not adjusted for lesser vegetative quantities. Continuous monitoring or livestock use, fencing, and other component practices, such as watering facilities, may likely al be necessary to fully achieve this practice's objectives. Installation costs of fencing and watering facilities to achieve a prescribed grazing objective may be high, possibly cost prohibitive, unless phased in over several years. Additional herding time is necessary regardless of additional structural measures, which will raise management costs. Maintenance costs will also rise with additional structural components. Livestock production gains and other natural resource benefits may be adequate in some operations however that may provide a higher level of acceptance, though not easily seen in the short-term.

4.4.1.4 COST

The initial start-up costs, installation of component practices to effectively meet a prescribed grazing plan may or may not be offset by the level of carbon sequestration gained through a carbon market. Further analysis is needed on pasture and rangeland grazing systems to determine carbon storage rates to better describe a cost.

4.4.1.5 IMPLEMENTATION CAPABILITY

Installation costs of component practices, additional herding management, fire prevention measures, and the likelihood of having to reduce livestock numbers and duration of grazing on pastures are likely to be barriers to a rancher in adopting this practice. There is still much uncertainty with how much carbon sequestration can occur on range and pasture lands under specific vegetative species, regardless of grazing practices. Monitoring this practice will likely rely mostly on records and some field investigations, which are not always reflective of overall health of vegetation and grazing management. The success of existing grasses may also limit the success of this practice. Native and introduced grasses will likely differ in carbon sequestration, operation and maintenance.

4.4.1.6 OPERATION AND MAINTENANCE CAPABILITY

Prescribed grazing is an intensive grazing management system for a rancher. Additional hands may be needed for herding, and fencing, if not already in place. Maintenance costs are higher because of additional structural components, such as fencing and watering facilities. Grazing timing is very dependant on water availability and climatic condition sin regards to vegetative growth and dormancy. Disease control and preventive fire measures need considered to maintain healthy stands of vegetation to meet contractual provisions likely to be enforced through any carbon market.

4.4.1.7 MONITORING AND VERIFICATION CAPABILITY

Keeping to a prescribed grazing plan may be difficult as well as its monitoring. Verification is likely to be even more difficult. Record keeping would likely be the primary means of monitoring with some field site inspections on vegetative health and characteristics. For carbon sequestration, soil testing would likely be needed to establish baseline conditions and then future levels. Further research and discussion needs to be accomplished to best estimate carbon sequestration potential on rangeland and pastureland species, soils, and grazing techniques, which would then assist in the development of a monitoring plan.

4.4.1.8 ANCILLARY BENEFITS

Any improvements on upland and riparian sites, regarding vegetation and soil stability, will benefit multiple natural resources. Less soil erosion, improved water quality, improved wildlife habitat, improved riparian habitat for multiple wildlife and aquatic species, greater livestock weight gain, and other benefits are sure to be achieved, though not immediately recognized. If livestock numbers are reduced or managed in such a manner that improves rangeland conditions, public pressures would likely decrease on ranchers, especially on public lands.

4.4.2 Range and Pasture Planting

4.4.2.1 DESCRIPTION

This planting practice is to establish native or acceptable introduced vegetative species on range and pastureland, such as grasses, forbs, legumes, and trees. In regards to carbon sequestration, improvements of vegetative stands or seeking additional diversity of species may be the objective, which may increase below-ground carbon storage. Above-ground carbon sequestration may be short-term and needs further analysis. See the Idaho NRCS web site for additional information on this practice:

http://www.id.nrcs.usda.gov/Engdwnld/construction_specs.html. Refer to Range Planting, Pasture and Hay Planting, and Upland Wildlife Habitat Management standards.

4.4.2.2 EFFECTIVENESS

The replacement of poor condition pasture or rangeland grasses and weeds to native or site-appropriate species, such as crested wheat, basin wild rye, and sage brush in sage-steppe regions or high quality grass forages on irrigated or dryland pastures, some amount of sequestration is sure to occur. The amount of course, depends on previous conditions, water availability, and species planted.

If Idaho replaced poor condition pasture and rangeland acres with the most appropriate and likely successful vegetative species, which may include some woody species, sequestration rates may be somewhat higher than under a prescribed grazing practice. If 2-5% of pasture and rangelands were re-planted and maintained, then there might be about 0.07 MMT CO_2/y sequestered. A 20-25% application would yield 0.5 MMT CO_2/y. Further research is needed to really predict what replanting rangelands to native or improved introduced vegetative species would do regarding carbon sequestration. A whole-project analysis would need to be done to better estimate actual carbon credits available for purchase.

4.4.2.3 ACCEPTABILITY

Improving existing range and pasture stands, through replanting or over-seeding, is likely always acceptable, because of the direct benefit to livestock and wildlife. Depending on available soil water and climatic conditions, the specie to be planted will vary. Livestock use, fencing, and other component practices, such as watering facilities, may likely be necessary for the establishment of new stands, unless grazing is completely deferred a couple of years. Installation costs of fencing and watering facilities to achieve a prescribed grazing objective may be high, possibly cost prohibitive, unless phased in over several years. Maintenance costs will also rise with additional structural components. Livestock production gains and other natural resource benefits may be adequate in some operations however that may provide a higher level of acceptance, though not easily seen in the short-term. Wildlife habitat should also be improved and species populations may or may not respond quickly depending on planted species and other conditions.

4.4.2.4 COST

The initial planting costs, along with any additional installation of component practices to effectively protect the new plantings the first year or two, may be offset by the level of carbon sequestration gained through a carbon market, but only likely through a long-term period. Further analysis is needed on suitable pasture and rangeland vegetation species to determine carbon storage rates to better describe a cost.

4.4.2.5 IMPLEMENTATION CAPABILITY

Planting costs, additional prescribed grazing requirements, fire prevention measures, and other non-typical operation factors are likely to be barriers to a rancher in adopting this practice. There is still much uncertainty in regards to how and what level of carbon sequestration can occur on range and pasture lands under specific vegetative species, regardless of grazing practices. Monitoring this practice will likely rely mostly on records and some field investigations, which are not always reflective of overall health of vegetation and grazing management. Conversion of grazing land to a permanent cover without grazing, if considered an alternative here, may be not be acceptable by the rancher due to the reduced number of acres.

4.4.2.6 OPERATION AND MAINTENANCE CAPABILITY

Maintaining a new stand of vegetative species in drought conditions may be difficult. Available soil moisture is critical to when planting and for long-term maintenance. If the soil moisture is not adequate at planting, seed germination may be limited and require replanting, adding costs. During low water years, drought conditions may lower desired plant vigor, and allow for annual grasses and weeds to encroach the stand, requiring additional weed control. Fire damage is likely to more severe occur on stands with excessive weeds and annual grasses. Prescribed grazing will be more critical to maintain vigorous stands of perennial grasses and forbs.

4.4.2.7 MONITORING AND VERIFICATION CAPABILITY

Maintaining a vigorous stand of perennial vegetation may require attention beyond typical maintenance that occurs on range and pasture lands in Idaho. Record keeping and some field investigations will likely be the primary means of verification of the practice. For carbon sequestration, soil testing would be used for establishing baseline conditions and future levels, though not likely need taken every year. Further research and discussion needs to be accomplished to best estimate carbon sequestration potential on rangeland and pastureland species and soils, which would then assist in the development of a monitoring plan.

4.4.2.8 ANCILLARY BENEFITS

Any improvements on range and pasture lands, regarding vegetation and soil stability, will benefit multiple natural resources. Less soil erosion, improved water quality, improved wildlife habitat, improved riparian habitat for multiple wildlife and aquatic species, greater livestock weight gain, and other benefits are sure to be achieved, though not immediately recognized.

4.5 LIVESTOCK RELATED ACTIVITIES

4.5.1 Reducing Methane (CH4) Emissions from Ruminant Livestock

4.5.1.1 DESCRIPTION

Most of the U.S. CH_4 emissions are due to livestock, both from the digestion process and from manure. Digestive processes of cattle account for 96 percent of these emissions. Further reduction of these emissions through more efficient feed rations is somewhat limited given the large feed efficiency gains over the last 20 years. However, digestive process CH_4 emissions can be further reduced through improvements in grazing-plant quality.

The breakdown of carbohydrates in the digestive track of herbivores (including insects and humans) results in the production of methane. The volume of methane produced from this process (enteric fermentation) is largest in those animals that possess a rumen, or forestomach, such as cattle, sheep, and goats. The forestomach allows these animals to digest large quantities of cellulose found in plant material. This digestion is accomplished by microorganisms in the rumen, some of which are methanogenic bacteria. These bacteria produce methane while removing hydrogen from the rumen.

In general, methane production by livestock represents an inefficiency because the feed energy converted to methane is not used by the animal for maintenance, growth, production, or reproduction. While efforts to improve efficiency by reducing methane formation in the rumen directly have been of limited success, it is recognized that improvements in overall production efficiency will reduce methane emissions per unit of product produced. A wide variety of techniques and management practices are currently implemented to various degrees among livestock producers which improve production efficiency and reduce methane emissions per unit of product produced. Improving livestock production efficiency so that less methane is emitted per unit of product is among the most promising and cost effective techniques for reducing livestock emissions. Specific strategies for reducing methane emissions per unit product have been identified and evaluated for each sector of the beef and dairy cattle industry. Throughout the industry, proper veterinary care, sanitation, ventilation (for enclosed animals), nutrition, and animal comfort provide the basics for improving livestock production efficiency. Within this context, a variety of techniques can help improve animal productivity and reduce methane emissions per unit of product.

Improved herd management, particularly improved nutrition and increasing the percent of cows producing calves, can reduce CH_4 emissions per unit of beef produced. It is estimated that widespread adoption of these measures could reduce CH_4 emissions from beef cattle by 20 percent.

For the dairy industry, significant improvements in milk production per cow are anticipated in the dairy industry as the result of continued improvements in management and genetics. Additionally, production-enhancing technologies, such as bovine somatotropin (bST), are being deployed that accelerate the rate of productivity improvement. By increasing milk production per cow, methane emissions per unit of milk produced declines. To increase milk production per cow, the industry is currently using a growth hormone known as bovine somatotropin (bST). By maximizing production per cow, overall emissions should decline with increased use. However, the use of bST is somewhat controversial because of health and safety concerns for both cows and humans.

Improving productivity within the cow-calf sector of the beef industry requires additional education and training. The importance and value of better nutritional management and supplementation must be communicated. Energy, protein, and mineral supplementation programs tailored for specific regions and conditions need to be developed to improve the implementation of these techniques. The special needs of small producers must also be identified and addressed. Cow-calf productivity can potentially play a significant role reducing emissions. Increasing the rate at which cows reproduce would reduce the number of breeding cows needed. In terms of methane emissions, this is important because the breeding herd required to sustain the beef industry is significantly larger than that in the dairy industry.

Ionophore feed additives provide yet another strategy for reducing emissions. These antibiotics are mixed into feed to improve the efficiency of digestion and use. Ultimately, less feed per cow translates into less methane per cow. A final strategy consists of using anabolic steroid implants. These implants increase the rate of weight gain in cattle, thereby decreasing the number of cows and the quantity of methane emissions per unit of beef product.

In addition to these near term strategies, several long-term options may prove viable depending on the success of ongoing research. These strategies include: 1) the transfer of desirable genetic traits among species (transgenic manipulation); 2) the production of healthy twins from cattle (twinning); and 3) the bioengineering of rumen microbes that can utilize feed more efficiently. Competitive pressures to increase efficiency will encourage the dairy and beef industries to adopt some or all of the short-term process changes described. Since 1950, however, the number of dairy cattle in the United States has declined by over 50 percent, proving the dramatic impact that production efficiency has had on the cattle industry. However, these numbers have increased in Idaho.

4.5.1.2 EFFECTIVENESS

According to industry estimates, methane emissions could be reduced by up to two percent per year if the above practices are employed. If the above discussed methods were used on 50% of Idaho's dairy, beef, sheep, hog, and pig populations, the estimated amount of methane reduced may be about 1.5 MMT CO_2e. The IPCC 1996 Tier one calculations were used to estimate Idaho's statewide potential, found in Appendix 7.

Rangeland livestock may or may not be much of a source of methane, in either case, it would more difficult to track and be effective in reducing methane, while they are not contained and primarily grass fed. However, some ranchers do utilize protein supplements that may increase productivity, thus less methane. If changes were made in diets of any ruminant livestock, and production was to be maintained for net profits, then any reduction in methane would likely be a result of reduced product, which then would be replaced by additional numbers of livestock, therefore, no net reduction in methane. A whole-ranch analysis would need to be done to better estimate actual carbon credits available for purchase.

4.5.1.3 ACCEPTABILITY

Competitive pressures to increase efficiency may encourage the dairy and beef industries to adopt some or all of the short-term processes, such as nutritional supplements. Long-term processes, such as the breeding techniques, will likely not be a priority for adoption at this time, with current markets.

4.5.1.4 COST

Costs for each alternative vary and long-term benefits may not easily determined. Long-term analysis of most of these alternatives may be the only method for estimating a cost. It is likely that the short-term practices, such as livestock supplements, may be least expensive with some return on investment, but may not warrant a substantial greenhouse gas market attention for individual operators. If numerous livestock operations pool resources, then the supply of credits (offsets) may be large enough to encourage buyers of these credits. Acceptability might increase if there shows a return on investment or with increased incentives through a carbon market.

4.5.1.5 IMPLEMENTATION CAPABILITY

Uncertainty in most of these practices will likely deter implementation. Willingness of a potential carbon buyer may be less with these practices because of uncertainties in the research and the long-term benefit to emission reductions. There will exist start-up costs and management changes necessary that may not fit in well with an existing operation.

4.5.1.6 OPERATION AND MAINTENANCE CAPABILITY

Continual operation of these practices where there lacks good science and understanding of their effect on livestock production and methane reductions may hinder a consistent operation of these practices. When an operator is convinced that a practice will succeed in reaching a set objective, such as a return ion investment, the continual operation and maintenance of a practice will likely occur for longer periods of time. While these practice are mostly management type practices, maintenance is not such an issue, such as with structural practices.

4.5.1.7 MONITORING AND VERIFICATION CAPABILITY

Record keeping is likely the key to verifying that the practice is being implemented according to contract provisions. Verifying that actual methane emission from individual livestock is virtually impossible, except under research conditions. Modeling, utilizing specific management inputs and scientifically-based data, may provide adequate estimates of the practice's effectiveness, which may or may not be adequate for a carbon market. Uncertainties may outweigh the potential benefit from implementing these types of practices where verification is nearly impossible.

4.5.1.8 ANCILLARY BENEFITS

If these practices do increase livestock production, then, hopefully, net income should increase per unit livestock, if markets acknowledges the improvement and pays more for the product. Greater attention to production may have unknown livestock health benefits, but also negative impacts on health or product demand, where supplements are concerned.

4.6 BIOENERGY DEVELOPMENT

Fossil fuel combustion is the major source of U.S. greenhouse gas emissions. The agricultural sector can help reduce reliance on fossil fuels in several ways. Agriculture residues and other products can be an energy source can help reduce reliance on fossil fuels. Plant materials can be used either to generate electricity or to produce transportation fuels (biofuels). Unlike the release of CO_2 from fossil fuel combustion, CO_2 released during combustion of plant materials and animal wastes is counterbalanced by the CO_2 that plants remove from the atmosphere during photo-synthesis. However, the overall net greenhouse gas benefits of biofuels are variable due to greenhouse gas emissions from the farming, transportation, and conversion methods currently used in the U.S. Where large amounts of animal wastes are available in a concentrated location, as in large confined animal feeding operations (CAFOs), CH_4 can be captured and used to generate electricity. The most significant constraints to utilization of animal wastes for power generation are: initial costs, the rates offered by utilities to small and medium-scale independent power producers; lack of access to capital; lack of appropriate farm-scale technologies; lack of standardized connection requirements; and lack of “net metering” requirements.

4.6.1 Biogas Recovery

4.6.1.1 DESCRIPTION

Biogas technology is a manure management tool that promotes the recovery and use of biogas as energy by adapting manure management practices to collect biogas. The biogas can be used as a fuel source to generate electricity for on-farm use or for sale to the electrical grid, or for heating or cooling needs. The biologically stabilized by-products of anaerobic digestion can be used in a number of ways, depending on local needs and resources. Successful byproduct applications include use as a crop fertilizer, animal feed, bedding, and as aquaculture supplements.

When livestock manure is handled under anaerobic conditions (in an oxygen free environment), microbial fermentation of the waste produces methane. Liquid and slurry waste management systems are especially conducive to anaerobic fermentation and to methane production. Because confined livestock operations such as dairy and hog farms rely on liquid and/or slurry systems to manage a large portion of their manure, they account for a majority of all animal manure methane emissions in the U.S., as well as Idaho. Emissions depend on farm characteristics (including number and type of animals, manure management practices, and animal diet) and climatic conditions (including temperature and relative humidity).

In order to comply with these federal and state regulations, many confined livestock operations (*i.e.*, non-grazing operations) are utilizing anaerobic lagoons or storage ponds to contain runoff and to manage their manure. These systems are simple, cost-effective, and relatively safe. However, because anaerobic systems produce more methane than aerobic systems, their increased use could significantly increase methane emissions from livestock operations. Most of the methane generated from these anaerobic systems could recover the methane and use it for energy instead of being vented to the atmosphere. A technique called anaerobic digestion (also known as anaerobic fermentation) can be used to maximize methane generation from livestock waste within a controlled, oxygen-free environment. The gas produced is called biogas (generally about 60-70% methane and 30-40% carbon dioxide) and can be used as a substitute for natural gas or combusted for electricity generation.

Feasible and cost-effective technologies exist to recover methane produced from the liquid manure management systems used at dairy and swine operations. Methane can be captured, for example, by placing a cover over an anaerobic lagoon. A collection device is placed under the cover and methane is removed by a vacuum. Alternatively, methane can be recovered from mixed tank or plug flow digesters that produce methane. These and other technologies can be used on individual farms or at centrally located facilities. Thus far, however, anaerobic digesters have only proven cost-effective in the U.S. for large livestock operations.

Some cost analysis of these systems has been done which provides some costs and benefit expectation with digester systems. Assuming facility livestock populations ranging from 250 to 1,000 head, installation costs range from about \$50 to \$260 thousand (USEPA 1993). Operation costs range from about \$1,000 to \$8,500. Annual benefits however, range from \$6,200 to \$42,000, with payback ranging from 6 to 21 years.

A primary drawback to methane collection from lagoons is the apparent lack of cost effectiveness when confined to a single farm. An important aspect of the cost is the corrosiveness of some of the gases produced, in particular hydrogen sulfide (H_2S). Mitigation measures that reduce this gas also have costs involved. For example, the necessary use of absorbents such as iron oxide adds labor and transportation costs to the cost of disposal. Once the methane has been collected, it may be flared, burned for heat, or burned or sold for electricity. Flaring produces no financial benefit but does reduce the global warming potential. Burning for heat may be beneficial, especially for farms at higher elevations, but since most farms do not require the amount of heat that can be generated, much of the heat would be wasted (USEPA 1993).

A typical biogas system consists of a system of manure collection, anaerobic digester, effluent storage, gas handling, and gas use. The manure can be handled by numerous methods. Raw manure consists of 8 to 25 percent solids, depending upon animal type. It can be diluted by various process waters or thickened by air drying or by adding bedding materials. Liquid Manure has less than 3 percent solids. This manure is typically "flushed" from where it is deposited, often using fresh or recycled water. Slurry manure consists of 3 to 10 percent solids. Slurry manure is usually collected by a mechanical "scraper" system. Semi-solid manure consists of 10 to 20 percent solids. This manure is typically scraped. Solid manure consists of greater than 20 percent solids and is handled as a solid by a scoop loader.

The digester is the component of the manure management system that optimizes naturally occurring anaerobic bacteria to decompose and treat the manure while producing biogas. Digesters are covered with an air-tight impermeable cover to trap the biogas for on-farm energy use. The choice of which digester to use is driven by the existing (or planned) manure handling system at the facility. The digester must be designed to operate as part of the facility's operations. One of three basic options will generally be suitable for most conditions:

- Covered Lagoon - Covered lagoons are used to treat and produce biogas from liquid manure with less than 2 percent solids. Generally, large lagoon volumes are required, preferably with depths greater than 12 feet. The typical volume of the required lagoon can be roughly estimated by multiplying the daily manure flush volume by 40 to 60 days. Covered lagoons for energy recovery are compatible with flush manure systems in warm climates. Covered lagoons may be used in cold climates for seasonal biogas recovery and odor control (gas flaring). Typically, multiple modules cover the lagoon surface and can be fabricated from various materials.

- Complete Mix Digester - Complete mix digesters are engineered tanks, above or below ground, that treat slurry manure with a solids concentration in the range of 3 to 10 percent. These structures require less land than lagoons and are heated. Complete mix digesters are compatible with combinations of scraped and flushed manure.

- Plug Flow Digester - Plug flow digesters are engineered, heated, rectangular tanks that treat scraped dairy manure with a range of 11 to 13 percent total solids. Swine manure cannot be treated with a plug flow digester due to its lack of fiber.

A gas handling system removes biogas from the digester and transports it to the end-use, such as an engine or boiler. Gas handling includes: piping; gas pump or blower; gas meter; pressure regulator; and condensate drain(s). Biogas produced in the digester is trapped under an air-tight cover placed over the digester. The biogas is removed by pulling a slight vacuum on the collection pipe (e.g., by connecting a gas pump/blower to the end of the pipe) which draws the collected gas from under the cover. A gas meter is used to monitor the gas flow rate. Sometimes a gas scrubber is needed to clean or “scrub” the biogas of corrosive compounds contained in the biogas (e.g., hydrogen sulfide). Since the gas storage space is limited (i.e., the volume under the cover), a pressure regulator is used to release excess gas pressure from the cover. Warm biogas cools as it travels through the piping and water vapor in the gas condenses. A condensate drain(s) removes the condensate produced.

Recovered biogas can be utilized in a variety of ways. The recovered gas is 60-80 percent methane, with a heating value of approximately 600-800 Btu/ft3. Gas of this quality can be used to generate electricity; it may be used as fuel for a boiler, space heater, or refrigeration equipment; or it may be directly combusted as a cooking and lighting fuel. Most equipment that uses natural gas, propane, or butane as fuel can be fueled by biogas.

Electricity can be generated for on-farm use or for sale to the local electric power grid. The most common technology for generating electricity is an internal combustion engine with a generator. The predicted gas flow rate and the operating plan are used to size the electricity generation equipment. Engine-generator sets are available in many sizes. Some brands have a long history of reliable operation when fueled by biogas. Electricity generated in this manner can replace energy purchased from the local utility, or can be sold directly to the local electricity supply system. In addition, waste heat from these engines can provide heating or hot water for farm use.

While waste-to-energy plants at individual farms are generally not cost-effective unless the farms are of moderate to large size, combining the waste from a group of neighboring farms may be significantly more economical. For example, this could involve construction of one or more small plants within high density dairy facility areas. The process may be centered on anaerobic digestion, wherein the waste is converted into biogas, granular fertilizer, compost, and irrigation water. The biogas fuels a generator, which satisfies most of the facility’s energy requirements. The fertilizer and compost produced are sold to plant nurseries, golf courses and landscapers, and the irrigation water is kept for moisture needs or donated to local farmers via a plastic pipeline. Wastewater to be used for irrigation water may need to be permitted by regulatory agencies.

A centralized plant for livestock biomethanation would have both positive and negative aspects. Benefits may include cost reduction per cubic meter of digester volume, smoother input, since variations in feed from one farm are partially mitigated by feed from other farms, and the opportunity to site the plant for maximum use of available animal waste. Disadvantages would include added costs for transport to the plant, increased complexity of administration, and possible additional odors around the plant.

4.6.1.2 EFFECTIVENESS

Depending on the number of large dairy and swine operations in a state, utilization of livestock methane can significantly reduce methane emissions. These systems can reduce emissions at individual farms by up to 80 percent (U.S. EPA, 1993b). Furthermore, developing methane recovery and utilization projects will have an immediate impact on reducing emissions since these systems can be installed within one year.

In Idaho, there exists approximately 810 dairy facilities (ISDA, 2002), where nearly 700 of those facilities contain less than 1000 head of cows, with a total of about 190,000 head. These facilities, individually, are not as likely capable of producing an adequate amount of methane for digestion through anaerobic conditions, to produce adequate bioenergy for substantial marketing, except through cooperatives and centralized facilities. Transportation of filtered waste liquids would need to occur, but within a feasible distance. Initial investigations indicate that up to a maximum of 20 centralized facilities may be physically installed in the state, primarily in the highest density areas. Those individual facilities, nearly 100, may be able to produce bioenergy from capturing and processing methane. All of these dairy facilities, however, would need to re-tool their existing storage systems to be able to capture methane. Most existing storage ponds are less than 10 feet deep and cover large areas of land, thus not effective as digesters themselves. Storage ponds are currently not the most effective for complete anaerobic fermentation of wastes, but are not effective as aerobic systems either.

If these small dairies were to divert wastes to centralized bioenergy facilities, then bioenergy may be feasible. Centralized facilities, however, would need to be placed in locations that liquids could easily be piped or transported by truck, within the shortest distances. The profits from facilities would need to more than cover the construction and operation costs for such an endeavor to be feasible. A total maximum number of bioenergy facilities, either placed at individual dairy facilities or at a centralized site (without dairy production), then up to 120 bioenergy facilities could be built. Until a further, highly comprehensive analysis is done regarding centralized facilities, the estimate here is very gross. Total metric tons of methane that could possibly reduced from bioenergy facilities on the larger dairy facilities is about 0.73 MMT CO_2e. The amount of nitrous oxide would be about 29,000 MT CO2e/y. The assumptions in the calculation are found in Appendix 7.

4.6.1.3 ACCEPTABILITY

The installation costs for such a system to capture methane to flare, pipe, or burn for alternative power generation is high, along with operation and maintenance costs, which may hinder the adoption of this practice on dairy facilities. Current potential for cost-share and outside funding, such as through a carbon market, may help with installation costs, and may help increase the potential for adoption. Widespread adoption within the state is unlikely unless installation and maintenance costs lower, alternative power generation demand increases, and outside funding sources become more available. Regardless of the funding sources, installation costs will need supplemented and operation costs may need supplemented if the operation cannot reclaim the cost through less power usage. State regulatory agencies will need to evaluate how these systems will work with existing requirements for odor and nutrient and waste management. If government subsidies, tax credits, or other initiatives could be used to make implementation of such measures more economical for operators, emissions reduction potentials could increase considerably.

Government initiatives for increasing the capture rate for methane emissions from animal manure could include both incentives and regulations. Possible incentives include tax rebates, low-interest loans and training workshops. Regulations could mirror those of several other states that currently require farms to more stringently manage their animal wastes (USEPA 1993a). Care must be taken to ensure that such anaerobic digesters work properly. When not working optimally, they can increase methane emissions from animal waste. It should be noted that policies regarding methane recovery systems may be compatible with policies encouraging the use of manure instead of commercial fertilizer. Methane recovery systems could be employed during the storage period before application to fields.

Recent trends in manure management, such as using anaerobic lagoons to meet requirements of the Clean Water Act, have prompted interest in developing and installing on-farm methane recovery systems. Many of the operational problems initially experienced with methane recovery systems in the early 1970s have been overcome during the past two decades through advances in the methane recovery industry. EPA's AgStar program focuses on providing support to farms considering implementing methane recovery systems. As of late 1997 there were 40 farm operations participating as AgStar partners.

Implementation of recovery systems usually focuses on large dairy or hog farms (for example, farms with over 500 milking cows or over 1,500 hogs) that use liquid or slurry manure management systems which are especially conducive to methane production. The current trend in livestock production is away from the small family farm (less than 200 cows) with limited manure storage capabilities toward large production farms (over 500 cows) that use manure storage systems as a matter of routine. This trend may mean that an increasing number of farms will find it economic to capture methane. Additionally, methane recovery and use may be more economical for farms located in a relatively warm climate.

According to the Idaho Department of Water Resources, the Energy Division, they launched a five-year effort to educate the dairy and livestock industry on anaerobic digestion processes and to help them incorporate digester technologies into their operations. A long-range goal was to install at least 5 digester systems on Idaho dairies in the Magic Valley area near Twin Falls, Idaho, by 2005. If regulations require odor completely controlled, then acceptability will not likely be such a factor.

4.6.1.4 COST

The potential for available methane to be sold to pipelines for distribution through the existing natural gas pipeline network has some limitations. When gas is produced from livestock manure, it is typically composed of about 40 to 50 percent carbon dioxide and trace quantities of other gases such as hydrogen sulfide (H_2S), which need to be removed before the gas can be injected into a pipeline. The cost of upgrading the gas to pipeline quality makes this option uneconomical at the current time. Methane must be processed before it can be used in most equipment. The amount of processing necessary depends on the specifications of the equipment and the characteristics of the gas. Small farmers' profit margins and numbers of animals, however, are not sufficient to afford new, energy efficient technology or the necessary CH_4 recovery technology.

4.6.1.5 IMPLEMENTATION CAPABILITY

Again, installation and operation costs will likely deter implementation of these methane recovery systems. Regulatory requirements must be met as and coincide with the system. Physical layout of existing operations may not fit well wit the systems without some additional component practices, which would increase costs, and effect, potential additional impacts.

In the U.S., there have been many reasons implementation prior to the early 1980s has not been successful (USEPA, 1993a). Reasons for biogas failure before were:

1. Operators did not have the skills or the time required to keep a marginal system operating.
2. Producers selected digester systems that were not compatible with their manure handling methods or layout of their farms.
3. Some designer/builders sold “cookie cutter” designs to farms. For example, of the 30 plug flow digesters built, 19 were built by one designer and 90 percent failed.
4. The designer/builders installed the wrong type of equipment, such as incorrectly sized engine-generators, gas transmission equipment, and electrical relays.
5. The systems became too expensive to maintain and repair because of poor system design.
6. Farmers did not receive adequate training and technical support for their systems.
7. There were no financial returns of the system or returns diminished over time.
8. Farms went out of business due to non-digester factors.

4.6.1.6 OPERATION AND MAINTENANCE CAPABILITY

Operation and maintenance is likely very involved, especially to a new user. There would be constant inspections of components, additional care in ensuring anaerobic conditions are suitable for electrical generators, heat generators, chillers, and other equipment. Operation will likely need to ensure that odors and other potential nuisance problems are monitored to stay in compliance with existing regulations. Fencing and other protective structures may need to be in place and maintained to ensure trespass is limited and employee safety.

4.6.1.7 MONITORING AND VERIFICATION CAPABILITY

Monitoring is going to be needed within a carbon market to ensure that the system is operating and being maintained properly, as well as annual verification of methane reductions (use). If the system is designed and functioning properly, then the calculated usage and reductions of methane emissions should be occur ongoing.

4.6.1.8 ANCILLARY BENEFITS

Where properly designed methane recovery systems are installed, odor requirements may be met when methane is flared off or utilized for power, heat, or chiller equipment. Less off-site power usage may be appreciated with these systems if adequate methane is produced. If a carbon market exists, where a emission source is in need of offsets, the facility may be a viable choice as compared to other carbon sequestration practices that are not as easily monitored and verified as increasing carbon storage or reducing other gases. Also the potential for ground and surface water contamination is reduced by the conversion of organic nitrogen to ammonium compounds through digestion.

Other benefits include: recovering biogas and producing on-farm energy, livestock producers can reduce monthly energy purchases from electric and gas suppliers; in the process of anaerobic digestion, the organic nitrogen in the manure is largely converted to ammonium, the primary constituent of commercial fertilizer, which is readily available and utilized by plants; digester effluent is a more uniform and predictable product than untreated manure. The higher ammonium content allows better crop utilization and the physical properties allow easier land application. Properly applied, digester effluent reduces the likelihood of surface or groundwater pollution; and heated digesters reduce pathogen populations dramatically in a few days. Lagoon digesters isolate pathogens and allow pathogen kill and die-off prior to entering storage for land application.

Biogas recovery can improve profitability while improving environmental quality. Maximizing farm resources in such a manner may prove essential to remain competitive and environmentally sustainable in today's livestock industry. In addition, more widespread use of biogas technology will create jobs related to the design, operation, and manufacture of energy recovery systems and lead to the advancement of U.S. agri-business.

4.6.2 Biofuels Production

4.6.2.1 DESCRIPTION

There is considerable interest in producing large quantities of alternative liquid fuel products from biomass, such as corn, wheat, barley and canola. Not only is this interest driven by the desires for greater energy security, but also by changes in federal policy promulgated under the Clean Air Act Amendments of 1990 and the National Energy Policy Act of 1992 (EPACT) which focus attention on the environmental impacts of transportation fuels. These legislative acts are stimulating the search for cleaner-burning alternatives to gasoline and diesel fuels. One alternative to gasoline is biomass-derived ethanol, which can be used in pure form or blended with gasoline to increase oxygenation and thereby reduce the amounts of certain pollutants. One alternative to conventional diesel fuel is biodiesel, which can be used in unmodified diesel engines. Biodiesel is produced from some animal fats or vegetable oils and canola after undergoing a relatively simple process called transesterfication. All Regional Biomass Energy Program (RBEP) regions have been involved in the area of alternative liquid fuels from biomass and continue to fund significant projects in this field.

Several short-rotation woody crops have been identified as "model" energy crop species based on their rapid biomass yield potential. These species include silver maple, sweetgum, sycamore, black locust, eucalyptus species or hybrids, and poplar species or hybrids. The highest yielding crop appropriate for a given region may depending on soil and other characteristics within a geographical region (Sampson and Hair, 1992). The National Academy of Sciences Mitigation Panel classify methanol and ethanol from wood biomass fuel as alternative fuel that eliminate greenhouse gas emissions (NAS, 1991). In corn processing, ethanol is produced from the starch-based carbohydrate fraction of the corn kernel. But the corn fiber represents about 13% of the ethanol that could be produced from the kernel (U.S. DOE, 1998). The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) seeks ways to economically increase the yield of ethanol from biomass such as corn fiber. Corn stover, crop residues, and/or other corn fiber could also be utilized in ethanol production.

4.6.2.2 EFFECTIVENESS

Burning ethanol in blends with gasoline (commonly 10% by volume) has a slight advantage over gasoline and diesel fuel from a greenhouse gas emissions standpoint. These emission factors in units of tons CO2 per million BTU (tons CO_2 /MMBTU) are given from the U.S. EPA (1995) State Workbook as: ethanol, 0.0760; gasoline, 0.0777 and diesel, 0.0799. But the big potential advantage of burning ethanol in lieu of gasoline is in the energy and CO_2 emissions that are saved by using renewable fuels. The energy in ethanol comes from photosynthesis and the sequestration of CO_2 from the atmosphere. Some energy is utilized and CO_2 emitted in the production of the ethanol, but, on a net basis, it saves energy and emissions.

Corn ethanol production creates 24 percent more energy than it uses, according to a study performed by the U.S. Department of Agriculture ("Estimating the Net Energy Value of Corn-Ethanol," USDA) which results in a net reduction in greenhouse gas emissions. Furthermore, the study found ethanol could replace petroleum imports by a factor of 7 to 1 because it uses abundant domestic feedstocks such as natural gas and propane.

With a significant level of activity around the country directed toward the development of alternative liquid fuel products from biomass, it seems inevitable that transportation sector emissions will at some point be reduced from the use of bio-fuels. The timing of those greenhouse gas emissions reductions as well as the specific fuels and technologies that will penetrate the market place are not clear at this time.

Renewable ethanol burns "cleaner" than gasoline and diesel (less CO2, CO, and hydrocarbons emitted). The controversy lies in estimates of the amount of nonrenewable fossil fuels that must be combusted to produce a gallon of clean burning ethanol. Most recent articles estimate energy requirements to be in the range of 50 to 100% of the energy equivalent in ethanol. Obviously, if 100% of the energy contained in ethanol is required to produce it using nonrenewable fossil fuels, then there is no greenhouse benefit. However, if only 75% of the energy in a gallon of ethanol is required to produce it, then a large benefit accrues in diminished CO_2 emissions because a renewable corn crop has been utilized, which sequestered CO_2 from the atmosphere during the growing season.

Various sources for biofuels and bioenergy include corn, sugar, and other products; biodiesel from soybeans and other products; electric power generation from animal wastes or generation grasses and trees grown in shelterbelts or on marginal & abandoned cropland. Biomass resources, including wood and agricultural wastes, timber, and grain crops accounted for about 3.3 percent of U.S. energy consumption in 1990. Because plants that produce these resources sequester carbon while growing, using biomass as a renewable energy source to displace fossil fuels helps mitigate carbon dioxide buildup in the atmosphere.

Utilizing biofuels to create carbon credits has the potential of increasing the benefit per acre of agricultural land beyond that of improving the land management practices. An example analysis of the total cropland acres needed to produce nearly 95 million gallons of ethanol is summarized in Table 7. For example, if up to 25% of the total acres of barley, wheat (variety ignored), and grain corn were used for ethanol production, if would result in 86.2 million gallons of ethanol. As seen in Table 1. corn has the highest emission offset per acre due the crops higher yield (150 bu/acre in 2001). Corn results in about 2.6 MT CO_2e per acre, whereas barley and wheat yield only 1.3 and 1.2 respectively. The total CO_2e offset would be about 0.57 MMT. The total acres (25% of total) used here is nearly 480 thousand. If the state wished to increase ethanol production to 100 million gallons per year, but maintain the same number of acres, then more acres of corn would need to be grown, with less barley and/or wheat.

Table 7. Estmated Ethanol Production with Existing Crop Base

Crops	2001 acres	2001 yield - bushels	ethanol acres	gallons ethanol	CO2e @ 13.2lb/gal or .0066 MT	metric ton CO2e/acre	% acres of total acres
corn, grain	45000	150	11250	4471875	29514	2.62	2%
Barley	670000	75	167500	26381250	174116	1.04	35%
Wheat	1200000	71	300000	55380000	365508	1.22	63%
Totals	1915000		478750	86233125	569139	1.19	100%

Table 8 shows the adjusted acreage of the crops to produce just over 100 million gallons. Corn acreage would need increased to about 16% of the total acreage of the 3 crop total. The new amount of CO_2e offset would then be about 0.67 MMT. A statewide project analysis would need to be done to better estimate actual carbon credits available for purchase. A discussion on ethanol and biodiesel potential in the state is presented in Appendix 3.

Biodiesel production was evaluated by looking only at canola production. One MT of oil seed produces approximately 110 gallons of biodiesel. One gallon of biodiesel, is used in place of diesel fuel, reduced CO_2 emissions by 17.7 lbs, or 0.008 MT. If 50% of the 2001 acres (22,500, 0.72 MT/acre production) of canola were used to produce biodiesel, then approximately 9,000 MT CO_2e could be offset per year. A whole-farm/project analysis is needed to determine the net CO_2e offset.

Table 8. Cropland Acres Needed to Produce 100 million gallons of Ethanol

	% of total	new total crop acres	25% of acres	gallons ethanol	CO2e @ 13.2lb/gal or .0066 MT	metric ton CO2e/acre
corn, grain	16%	306400	76600	30448500	200960	2.62
Barley	28%	539300	134825	21234938	140151	1.04
Wheat	56%	1069300	267325	49348195	325698	1.22
Totals	100%	1915000	478750	101031633	666809	1.39

4.6.2.3 ACCEPTABILITY

There are many issues that may impact biofuels supply and demand. Many issues surrounding the use of ethanol from corn, such as the use of methyl-tertiary-butyl ether (MTBE) rather than ethyl-tertiary-butyl ether (ETBE) in reformulated gasoline, price subsidies required for ethanol and ETBE from corn, disputed air quality benefits of smog and ozone formation, ethanol trade barriers with Brazil, strategic reliance on foreign oil, balance of payments, the cost of maintaining a military presence in the Middle East to protect oil supplies, energy self-sufficiency, and soil erosion as a result of a renewable crop such as corn. Currently, only tax incentives exists to the sales of ethanol, not production. If this was applied to production of ethanol, the supply may increase if other barriers were removed and demand was high.

4.6.2.4 COST

While the market price for a barrel of oil is about $20, the U.S. General Accounting Office estimates its true cost is really about $126 per barrel. When calculating the real cost of gasoline, ethanol becomes even more attractive. The cost of building a biofuels facilities is no doubt expensive. However, the demands for ethanol, for example, would return substantial profits if the market exists, in fact, likely within a few years. Costs, then are soon recovered if demand is high.

4.6.2.5 IMPLEMENTATION CAPABILITY

The biggest problem facing increased reliance on ethanol from corn at the present time is when the price of corn reaches levels, such as more than $3 per bushel, and the politics of maintaining federal and state subsidies to make it cost competitive. There is a potential for ethanol to increase as a result of the 1990 Clean Air Act Amendments as ethanol is used in areas trying to meet mandated ambient air quality standards for ozone.

Environmental or toxicity characteristics may be associated with the new fuel. Institutional resistance to alternative fuels could be significant: converting to any of the alternative fuels at this point does not offer additional, tangible, and recognized benefits to vehicle operators. Without the certainty of a customer base, few suppliers would venture into the alternative fuels arena. Alternative fuels policies may, therefore, need to address both supplier and customer concerns to ensure program success. Currently, the refueling infrastructure exists in the state to support ethanol production and use, except for parent company restrictions on its mixing.

4.6.2.6 OPERATION AND MAINTENANCE CAPABILITY

With any new facility, there will be a great amount of operation and maintenance measures taking place. The level of maintenance may increase with the age of the operation, where equipment repair or replacement will occur more frequently. Maintaining a feasible operation will require some level of marketing, ensuring adequate biomass is available and being shipped to the facility for processing.

4.6.2.7 MONITORING AND VERIFICATION CAPABILITY

Based on the facilities operation records, if under a carbon market contract, the actual production and use of biofuels may be verified. Some record of the actual addition of biofuels to petroleum fuels and its sale at each of the service station may be used to verify actual us of the biofuels.

4.6.2.8 ANCILLARY BENEFITS

The use of biofuels may provide an unlimited industrial market for agricultural products beyond the limited traditional feed and food markets, and thereby stimulate rural investment and employment opportunities. The environmental benefits of reduced air emissions and the biodegradability of biodiesel would provide additional benefits for communities and metropolitan areas with air quality problems. Further, the nation would enjoy increased energy security from the reduction in imported oil. MTBE could be replaced by ethanol.

4.6.3 Cropland and Forest Biomass Energy Source

4.6.3.1 DESCRIPTION

Agricultural residues can be used as an alternative (biomass) fuel source for cooking, space heating, drying of agricultural products, and the production of power by steam engines or motors. Specific applications include burning the residues in furnaces to generate heat for drying units or for space heating at home. Combustion for heat generation may be the most appropriate means of replacing fuel oil with residues, because much less investment is necessary compared to replacing fuel oil in power generation. Also, the total maximum efficiency of the power produced by means of a turbine or steam engine is approximately 15 percent, even though the combustion of biomass can be accomplished with high efficiency.

Wood wastes and agricultural crop residues are often considered to be the most cost-effective biomass resources since they result from other productive economic activities and are readily available. Wastes and residues are currently used extensively for energy production in some sectors such as the paper industry. In addition to replacing fossil fuels that produce greenhouse gas emissions, increasing the use of these resources may help alleviate other problems such as costs and methane production associated with waste disposal and landfills. Wood and crop residues can be gasified, liquified (into ethanol), burned directly for use in on-site power generation, or burned to heat commercial buildings and homes.

Short rotation woody crops can be burned to heat buildings or to fire conventional power plants in a process similar to coal combustion. For example, in 1990 New York state generated around 3 megawatts of electricity using wood power and in 1991 Vermont generated approximately 1.7 percent of its electricity from biomass at a woodchip burning plant. Wood can also be transformed into liquid fuels such as ethanol through enzymatic processes, although these processes are expensive to use at the current time. Several short-rotation woody crops have been identified as "model" energy crop species based on their rapid biomass yield potential. These crops include silver maple, sweetgum, sycamore, black locust, eucalyptus species or hybrids, and poplar species or hybrids. The highest yielding crop appropriate for a given region may be among these model crops or may be different, depending on soil and other characteristics within a geographical region (Sampson and Hair, 1992).

Biomass has supplied approximately 9 percent of the total energy used in Idaho in recent years and there potentially is enough biomass waste (forest and logging residue, municipal solid waste, agricultural residues, animal waste, agricultural processing residue) to supply all the energy Idaho uses (http://www.idwr.state.id.us/energy/alternative_fuels/bio.htm).

Some facilities in Idaho have used biomass for many purposes. A new wood pellet mill feedstock dryer at the Jensen Lumber mill in southeast Idaho, a biogas cleaning system at the Nampa Wastewater Treatment Plant and a small backpressure turbine at the Ceda-Pine Veneer mill in Samuels are some examples. The University of Idaho has installed wood-fired boiler for campus heating and cooling.

Increased use of biomass can reduce the use of fossil fuels. Highly efficient and clean systems of residential, industrial and commercial scale wood energy technology exist and have found increasing use throughout the country. When biomass is grown sustainably and used to displace fossil fuels, or crop residues utilized, net carbon emissions are avoided since the CO_2 released in converting biomass to energy is sequestered within the regrowing biomass through photosynthesis. There is no such advantage with fossil fuel energy since the coal, oil and natural gas only make a net carbon increase to the greenhouse gas equation.

Through silviculture practices, such as related to forest land fire prevention or alternative use of crop residues, there is significant available amount for additional bioenergy facilities. There are virtually unlimited end uses for wood and some end use markets are, or potentially could be, extremely large. Some of the major end uses for wood waste include fuel and wood pellets. Wood waste may be processed and used as fuel in residential, institutional, municipal, commercial, industrial, or utility boilers or furnaces for the production of thermal and/or electrical energy. Wood may be used as the only fuel or it may be cofired with other fuels, such as coal and oil. Combustion equipment may be specifically designed to burn wood, or may be retrofitted equipment originally designed to burn other fuels.

4.6.3.2 EFFECTIVENESS

The efficient utilization of excess forest wood (waste) and crop residues in Idaho as an alternative energy source could have a positive affect on the state's greenhouse gas emissions, a well as the local economy. Advantages of processing wood from forested land, through timber harvesting practices or fire (disease, etc.) prevention measures, include reduced greenhouse emissions and smoke, reduced risk of severe fires, and reduced fossil fuel use. Domestic generated wood wastes may also utilized for bioenergy instead of dumped in landfills. The use of wood and crop residue as fuel has some air emission benefits compared to fossil fuels. Due to the low sulfur content of wood, significantly less sulfur dioxide, reduced sulfur compounds, and sulfuric acid are emitted than during fossil fuel combustion. Carbon emissions may also be reduced compared to fossil fuel combustion. Wood and crop waste may be cofired with coal in utility and industrial boilers, resulting in significant acid gas emission reductions. Air pollution control regulators and permit engineers are familiar with the combustion characteristics and emissions of clean, untreated wood. Research, demonstration, and operating experience indicates that several types of treated wood waste may be burned with minor or no negative impact on air and ash emissions.

If Idaho wheat, barley, and bluegrass residues were utilized in the production of bioenergy, a substantial amount of CO_2e emissions could be reduced. The Chariton Valley Biomass Project in Iowa showed that by utilizing switchgrass, about 0.52 MT CO2e/y emissions could be reduced, replacing a percentage of coal in a power plant. Grass and coal would be cofired, where 12.5 tons per hour would be used along with the coal. Where Idaho's wheat, barley, and bluegrass production and remaining residue is less, by about ½ of switchgrass, an gross amount of CO_2 emissions could be reduced in cofiring plants. This estimate is not dependent on existing or potential energy or similar plants, but on the capability and available amount of residues.

If crop residues were used on co-fired plant, where similar amounts were used in place of fossil fuels, such as coal, there could be could reduction in CO_2 by about 1.3 MMT where over ½ of those residues previously burned were used instead. The use of wood wastes in cofirng plants would produce a greater amount of CO_2 reductions on a per tonnage basis, where the density of wood is much greater than straw or grass residue. The heating capability of coal is higher than wood, possibly 1 to 3 times as high. Depending on the coal type, or other fossil fuels used, 1 to 3 times more biomass residue may need to be used for equivalent power or heat generation. where coal most available to Idaho (bituminous), produces about 20 or more million Btu's per ton, where wood generates about 17.2 million Btu's per ton. The comparison of wood to coal for heat generation shows that though wood is slightly less, the value wood as an alternative to coal is substantial. Emissions are substantially offset as well, where additional emissions of compounds are eliminated or reduced.

The amount of wood on forest floor is about 1 MT C/acre in a poorly stocked or non-stocked forest (see Appendix 2). If only 50% of forest floor wood litter is collectable for bioenergy use (0.5 MT C/ac or 1.8 MT CO_2e) and 0.52 MT CO_2 is offset per MT of biomass (wood), then 0.95 MT CO_2/acre of offset may result. If a total of 10% of those poorly stocked forest lands (about 350,000) were to provide wood for fossil fuel replacement, then about 0.3 MMT CO_2e could be offset. The amount of carbon previously sequestered in the wood however, if not captured during its burning, would need to be discounted in estimating a net offset. A whole-project analysis would need to be done to better estimate actual CO_2e offsets.

4.6.3.3 ACCEPTABILITY

Market and institutional barriers prevent industry and small business from choosing wood energy over fossil fuels. The lack of a fully active technology transfer program also hinders the appeal of biomass as an energy source. The market potential for wood waste used as fuel here in Idaho is not realized, therefore, a market for wood-generated energy is unlikely to be developed within the near future. Currently Idaho Power has only 3 coal fired power generation plants for the state. If coal was used more widely in the state, this alternative use of residues would likely be more important to the state.

4.6.3.4 COST

The total costs of biomass fuel development will vary depending on crop productivity and biomass handling and transportation costs. The benefits from utilizing renewable biomass is simply greater than using fossil fuels, though not always easily measured. Costs of using either source, however is. From the planting to harvest to its use, biomass costs may be calculated based on its actual production and utilization. Fossil fuel production and its use costs may also be calculated. These differences in costs need to be compared to for an operation to evaluate its operation effectiveness and its long-term operation. Benefits from using biomass instead of fossil fuels, in regards to carbon sequestration and emission reductions, would need to be measured or calculated with effective models to determine an actual cost. Some estimates , though, seem to indicate that there is a high cost, especially if regulatory policies com into effect on industries, where fines may be imposed if it does not meet emission objectives. If forest products were to be used for bioenergy, collection, onsite preparation, and transportation preparation would be expensive

4.6.3.5 IMPLEMENTATION CAPABILITY

Again, there must be a market or cost-effective purpose of collecting, separating, and processing wood wastes for one to adopt such a practice. If costs are offset by the benefits of reducing landfill wastes, reduced reliance of petroleum-based fuels, and other needs, then this practice may more readily be adopted. The infrastructure is really not in existence, therefore would need to be built first. There very steep conditions within forested areas, which would make forest wastes difficult to collect and transport to nearby roads. There is little demand for co-fired electrical demand in the state, therefore, reduces implementation.

4.6.3.6 OPERATION AND MAINTENANCE CAPABILITY

The challenge for biomass in the future is to ensure a sustainable harvest, possibly from plantations, to develop efficient and non-polluting systems for fuel conversion and use, and to lower production costs so these fuels can compete with traditional sources. A variety of factors affect wood waste processing facilities. This is particularly true because processing facilities require successful operation of two distinct components. One component involves obtaining sufficient supplies of wood waste. The second component involves securing a reliable demand, and suitable price, for products recovered from the wood. In some locations, there is an adequate supply of wood needing “disposal,” but there are insufficient end use markets. In other locations, the reverse is true. Major factors affecting wood waste processors include: existing solid waste and recycling programs, policies, and regulations; the availability of wood waste for processing; the extent of end use markets; and specifications for end products. These factors affect a processor’s selection of equipment, determination of the appropriate capacity of a facility, and facility location.

4.6.3.7 MONITORING AND VERIFICATION CAPABILITY

The primary monitoring tool may be the at the user end. If a supply of biomass is used by an industry for heating, processing, or energy production, and the source is known, then the quantity used may establish the carbon credit or emission reduction through calculations. Record keeping and periodic audits would need to occur, at least annually, to ensure that emission reductions are indeed happening, where fossil fuels have been replaced with biomass.

4.6.3.8 ANCILLARY BENEFITS

Landfill owners themselves can also benefit from separating wood. A number of landfill operators have invested in wood processing equipment or allow another party to process it. The landfill stockpiles wood that is delivered by haulers and then processes the waste. The purpose is either to reduce its volume or to sell for reuse. Some landfills may charge a lower tipping fee for wood separated from other waste before it is delivered to the landfill. Forests cleared of excessive deadfall, then used for other purposes can benefit from fire prevention or excessive devastation. Cleaner air would occur if crop residues were not burned on fields and was used instead for bioenergy production.

4.7 FORESTED, TIMBER LANDS

Professional management of forestland can result in multiple natural resource improvements, as well as maximum stocking and productivity of forestland acreage in our state. Increased productivity can maximize the carbon sequestration benefits. Silvicultural (forest management) practices to increase tree growth, adjust species composition and insure optimum stocking will yield beneficial carbon sequestration on existing forestland resources of our state.

Wood utilization technology is also being developed nation-wide by the forest industry and the federal government to meet the demand for wood products with low value, previously underutilized timber. Doing so may mean that less wood residue is left on the forest floor or discarded at the mill to decay. The carbon benefits derived from improved wood utilization depend upon the degree to which such utilization allows for reduced harvests of virgin timber.

Trees and other vegetation remove, or sequester, carbon dioxide from the atmosphere as they grow, storing it as carbon in trunks, limbs, roots, and soil. Through this process, forests provide an important terrestrial "sink" for CO_2. Furthermore, wood products are relatively long-lived structures that store carbon, which makes up about half the dry weight of wood, rather than allowing it to be released back to the atmosphere. Forest-related land use changes can affect the carbon sequestration in a number of ways.

Many practices can improve forest productivity and health, which are discussed below. Some other silviculture and forest-related practices are further discussed which include pest management, fire management, afforestation and reforestation, rural/urban residential tree planting, riparian conservation/restoration and forest biomass energy source.

4.7.1 Improve Forest Productivity and Health

4.7.1.1 DESCRIPTION

By increasing the productivity of forest species, demand for forest products could be met with fewer trees extracted, less carbon released to the atmosphere, and potentially more carbon sequestered. Management approaches that can be used to improve timber stand productivity and carbon sequestration include: Stand composition control, stand density control, protection and salvage (includes disease control), controlling rotation length, regeneration harvesting, edaphic (site) modification, fire management and forest insect and disease control. See Appendix 2 for additional information regarding forest practices.

4.7.1.2 EFFECTIVENESS

As mentioned before, substantial gains in carbon sequestration are possible through increased forest health and prevention of losses. Vigorously growing trees sequester carbon more rapidly than poorly growing ones. Stored carbon can be high in uneven-aged stands as there is a continuing stand of trees at all times. Carbon flux will depend on how intensively this harvest method is practiced. Sequestration is enhanced through the frequent extraction of forest products.

Tree species differ in carbon sequestration ability, by growth rate and density, so quantifying the amount of stored carbon with high level of certainty is difficult without site-specific data. Quantification can be, however, based on some givens, such as soil types and tree species, where previous data has been collected on similar sites. Trees with more dense wood contain more carbon per unit volume. Examples are Douglas-fir with a specific gravity of 0.473, ponderosa pine with 0.416, spruce/fir with 0.349 and western larch at the highest with 0.508 (Birdsey, in Sampson et al. 1992). Changing the species mix can affect the amount of carbon sequestered, either positively or negatively.

Silviculture practices themselves may not be measured directly, as one would in a specific tree, but may be considered an indirect positive effect on carbon storage. It may be that these practices can be viewed as some form of insurance or amount to offset an carbon market's uncertainties with specific practice implementation.

Some estimates have been made on how much sequestration and emissions reductions might occur with silviculture practices implemented, like these discussed here. If Idaho adopted these silviculture practices on 50% of its state and private forest lands, a significant amount of CO_2e could be sequestered. Very few field studies seem to be available to estimate accurately benefits in carbon sequestration and emissions reduction. A whole forest-wide project analysis would need to be done to better estimate actual carbon credits available for purchase.

4.7.1.3 ACCEPTABILITY

While public forest may be intensively managed, most private non-industrially owned forest is not. Various studies identify a number of reasons why nonindustrial timberland owners may not manage their forests for higher productivity. First, many landowners are not aware of what can be done to improve forest growth. Second, among those who are aware of the opportunities, many may be unwilling to undertake projects with a long payback period or relatively modest rates of return. Third, many lack the up-front capital needed to invest in a crop that, although profitable, may not generate income for 10 to 15 years. Additionally, landowners may resist investing in improving their forested land because of the low financial liquidity of young stands and an inability to use future forest values as collateral. Last, some landowners use their timberland for other purposes, such as recreation, which do not require high productivity.

Often, funding is limited for land owners who are desirous of participating in programs to prevent or control insects or diseases that kill or damage trees. Increasing the opportunities for monetary returns associated with increasing forest health will help stimulate forest owners be able and willing to participate in these activities. Finding new uses, of timber products, such small diameter logs that result from thinning is an example, where there is a demand, may help improve acceptability. Sale of carbon credits by forest owners may have potential for providing increased returns from forested acres, stimulating increased participation in all programs.

4.7.1.4 COST

The benefits of silviculture practices may be great towards carbon sequestration if regeneration, fast growth, and fire suppression occurs. The benefits are not easily quantified here but should be further evaluated and researched. Individual forest acreages and practices would need evaluated individually to assess a long-term carbon sequestration amount. Some modeling may be adequate to encourage the adoption of specific practices and sale of carbon credits with some level of certainty at this date. There is a higher level of certainty for above-ground biomass generation of carbon as compared to below-ground biomass and soils. Though initial costs may be greater, the cost of adopting pest management may be offset through forest health improvements, with the sale of good quality timber.

4.7.1.5 IMPLEMENTATION CAPABILITY

These silviculture practices can be implemented, and successful, if the landowner or forest manager is committed to a long-term plan. If the landowner can absorb initial costs, periodic natural setbacks, such as fire and disease, then ultimately this and similar practices can be implemented successfully, over a long period, meeting the landowner's objectives. If there is sustainable production occurring along with these practices, then implementation is likely to continue where a net profit is seen. Flexibility must be a part any long-term forest conservation and productivity plan.

4.7.1.6 OPERATION AND MAINTENANCE CAPABILITY

Timber management is generally not based on short-term decision making, but long-term objectives. Keeping to a management program that has little or no return on investment may be difficult maintain. However, if there is already an established forest that is steadily producing a product, where gradually, benefits are seen with improved management, the operation may be provided some encouragement seeing results in its products. While under a contractual agreement, continual implementation will be necessary, and hopefully, within that agreement, there are stipulations and understandings on what is needed to ensure proper operation and management. Again, as mentioned before, natural setbacks, market variability, and other factors will occur, therefore, the landowner needs to be flexible within its operation and maintenance plan.

4.7.1.7 MONITORING AND VERIFICATION CAPABILITY

Conceptually, improved timber stands and growth will increase carbon sequestration and effect positively other natural resources. Evaluating silviculture and its effectiveness may be difficult, if one was to attempt to measure it directly, such as in reduced decomposition or below-ground biomass production and soil carbon. Research activities have been ongoing looking into carbon cycling under various scenarios, but on a limited scale. costs and time input are high research projects, where physical data collection is time consuming. Actual data collection, under a carbon market, used to verify and quantify carbon stored, and would not likely be feasible. Research data collected on specific sites may be used to estimate what occurs on other similar sites. Modeling may be the most effective and feasible method for a carbon market. Uncertainties with modeling would be acknowledged in a market, reflected in prices and contractual provisions. Ensuring silviculture practices are being utilized correctly, over a long period of time, may simply be based on records and periodic inspection by a qualified forester.

4.7.1.8 ANCILLARY BENEFITS

Multiple natural resource benefits should occur with good management practices within a forest. When good silviculture practices are implemented, disease and fire damage is limited, thereby, reducing the sometimes devastating impacts to water bodies and wildlife habitat. Enhanced timber production is an objective within silviculture practices, where hopefully, a greater benefit to a landowner if implemented properly.

4.7.2 <u>Afforestation and Reforestation</u>

4.7.2.1 DESCRIPTION

Afforestation is the process of converting non-forest lands into forest stands. Afforestation of marginal cropland, pasture and riparian areas increases forestland acreage on open land not being productively utilized could provide substantial greenhouse gas benefits by planting trees on these properties. Tree species, particularly productive in sequestering carbon and/or fixing soil nitrogen, could be selected to obtain maximum greenhouse gas advantages per acre. Reforestation is simply replanting an area recently harvested for timber products or where trees have been damaged by fire or disease.

One example is where center pivot irrigation systems, commonly installed on large tracts of land, (80 to 160 acres), attempt to irrigate about 6 acres in each corner of the tract. The efficiency of such irrigation is usually low, and crop production limited. Many center pivot owners do not adequately irrigate these corners because of their inefficiencies, often letting some or all of the corners set idle. These irregular shaped corners also make maneuvering equipment difficult, however in areas where precipitation is adequate for crop production, farmers may still resort to dry land cropping. There are many acres of center pivot corners that could be planted to trees and shrubs to provide wildlife habitat and crop protection, while storing carbon, if adequate water was made available during establishment.

The following afforestation activities were evaluated:

- Poorly stocked forest land
- Non-stocked forest land
- Marginal cropland land

- Marginal pasture land
- Center pivot corners

4.7.2.2 EFFECTIVENESS

New forest plantings will cause an immediate increase in carbon sequestration on these sites. Reduced tillage within these areas will also reduced soil carbon losses in soils having been depleted by conventional tillage. Abandoned pasture and croplands are able to sequester C through the natural re-growth process. However, converting this land to managed forests allows for more C to be sequestered at a faster rate because youthful trees, generally through the first 10 to 20 years, maximize their uptake of CO_2.

Afforestation, new forest lands, seems to have the largest potential for carbon sequestration. Not only does creation of new forest inventory imply a large new carbon sink, increased forest products have long-term carbon storage properties. Lands converted from a use to forest land, may likely be those low-productive agricultural lands, or those being encroached upon by development, no longer viewed as prime farmland where production activities are susceptible urban pressures.

It is difficult, practically impossible to predict how many acres would be converted to new forest lands, there is data on the rate per acre of relative carbon fixation that could be generated. These conversions measure soil and biomass carbon, but calculate only net carbon gain between uses. Many variables and different combinations of these variables make it very difficult, if not impossible, to accurately predict a maximum level of carbon that could be sequestered in Idaho forests. However, if some assumptions are were made, a predicted level of carbon sequestration can be estimated through afforestation on specific land uses.

Afforestation might be financially feasible on only 20% of the biologically suitable acreage. Poorly stocked forest land may be under-stocked by 75%. Marginal pasture land is more available than good condition pasturelands. Marginal cropland has little or no carbon in the top one foot due to repeated tillage and may more likely be available for afforestation. If about 500,000 acres of these lands were converted to trees, there might be up to 3.7 MMT CO2e/yr sequestered. Further analysis would need to be done on site-specific areas to estimate a net carbon sequestration.

4.7.2.3 ACCEPTABILITY

Within the agricultural sector, giving up cropland is not readily acceptable, even if production is low. Aesthetics and wildlife benefits play a large role in causing landowners to plant some lands into trees, shrubs and grass. In southern Idaho, irrigation is needed to establish plantings, and longevity. Irrigation costs may need to be offset if large acres are planted. Small acreages may be easily incorporated into the much larger irrigation costs of farming. In orchard areas, increased wildlife habitat may increase fruit tree damage by wildlife, such as rodents and deer. Planting costs may be high, which may hinder the acceptability as well, with loss of some annual return from crop production. If the newly planted acreage can be considered alternative to cropland, property taxes may change, hopefully less while no annual profit is expected. Reforestation is required under Forest Practices Act regulations, within harvested forests, therefore, would likely be implemented regardless of how acceptable.

4.7.2.4 COST

The benefits of newly planted forests and timbered areas can be substantial in regards to carbon sequestration and reduced greenhouse gas emission reductions, primarily on intensively used lands. This practice will provide emissions offsets primarily in carbon storage. Above- and below- ground biomass will create the most stored carbon. Some soil carbon increases may be expected, but only in those soils where because of previous land use, organic matter has been reduced. If carbon markets become active in Idaho, the benefits should be great enough to offset planting and maintenance costs. Additional benefits in aesthetics and wildlife habitat could also be considered in a cost analysis for a landowner. If trees are grown for a specific product, then those expected returns would be realized upon the sale of the product, while estimated prior to the sale.

4.7.2.5 IMPLEMENTATION CAPABILITY

Once a landowner decides to convert a field to trees, implementation is easily achievable. The most difficult period is in making that decision. Planting trees or shrubs can be expensive if large acreages are involved. It may be best, however, to create a rotation and multiple age classes and species by planting only so many acres every year. This diversity in age classes may be wise to maintain so that damage from disease and other impacts may be less on the entire area planted. Cost-share programs and other funding sources may help in the implementation of such a practice.

Alternatives to completely setting aside acreages just for tree production may be considered. For example, trees may be incorporated into grazing areas, such as pastures, if woody utilization is controlled. Alfalfa hay could be planted within tree rows and utilized for livestock feed, though such a species competes with tree production and management would need adjusted to optimize carbon storage in the trees.

4.7.2.6 OPERATION AND MAINTENANCE CAPABILITY

Upon installation of new forest setting, disease control, irrigation, fertilization, and other operational and maintenance management needs to occur to ensure good health and long-term growth. Depending on the landowner's commitment and long-term objectives for the tree stand, the operation and maintenance will vary. If there is an expected return on the trees, then maintenance is likely going to be more important and likely carries out. If these plantings are on small acreages and to be permanent, then maintenance will likely occur as readily, because of there being no return on investment. If the landowner is in agreement and under a contractual arrangement with a carbon credit purchaser, then maintenance will simply have to occur in order receive payments or other incentives.

4.7.2.7 MONITORING AND VERIFICATION CAPABILITY

Periodic inspections will likely be all that is needed to verify that trees are growing adequately and being maintained. This practice is so visible that a higher degree of certainty exists. Where all parties can see results. Carbon sequestration could be physically measured through biomass production and core samples, but may be costly. Soil samples may be a part of the verification as well, but would require additional time and costs.

4.7.2.8 ANCILLARY BENEFITS

Increase wildlife habitat, aesthetics, reduced farm operation inputs (e.g. fuel use), and other benefits may be enjoyed with such a practice. These plantings may provide additional benefits, such as reduced odor and visual problems along side dairies, feedlots, and industries. Water quality may also benefit from greater vegetation diversity within the catchment provide by additional forested lands.